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GOUT AND RHEUMATISM.

23

GOUT AND RHEUMATISM:

AND

THE CURATIVE EFFECTS

OF

GALVANISM.

BY

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NATURA NIHIL AGAT FRUSTRA.

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PREFACE.

In directing attention to Electricity, or more strictly speaking Galvanism, and its curative powers, I by no means pretend to develop either the nature of a new agent or a new application of it, in the character of a therapeutic. The history given in the text at the beginning of this essay will secure me from any such imputation.

When the medical properties of electricity were first manifested, enthusiasts imagined that they had discovered a universal remedy; and from the numerous failures consequent on such unlimited application it fell into disrepute, and instead of holding the place of a powerful therapeutic directed by professional science, it became and remains to this day, chiefly a source of emolument to ignorance and empiricism.

Under the consideration that medical men generally look upon this branch of physics as one but very remotely connected, if indeed at all, with practice, and therefore devote but little time to its study, it seemed excusable to appropriate a portion of the following pages to a general outline of electrical science; I have therefore given in the first place a concise detail of the general history, nature, and powers of electricity.

Having, as it were, initiated the reader into the first rudiments, I proceed to those relations which more intimately connect the phenomena of electricity with those of life. Thus, in the remarks upon electro-physiology, the effects of the agent, not only upon the animal tissues and economy, but even upon the vital principle itself, are shown and explained.

Electrolysis or electro-chemical decomposition is next examined; but the above details being merely supplementary to the immediate object of this little work, have been treated with brevity and conciseness, and yet it is to be hoped without any sacrifice of clearness or perspicuity.

Passing on from such preliminaries to the introduction of electricity as a remedial agent in disease, I have ventured to introduce it to the reader as a valuable therapeutic in the treatment of gout and rheumatism; and in illustration, I have given a few out of many cases which fully warrant the opinion of its powers which I have advocated. At the same time, I am aware that galvanism, as a branch of medical science, has to encounter many difficulties, not from the prejudice alone with which it is regarded, but because the application is both troublesome and tedious, and, what is more, requires an amount of patience and a sacrifice of time which men in extensive practice will hardly afford.

There is but one more point to which I shall allude. Many who have witnessed or experienced the effects of electricity as exhibited at the various scientific institutions, run away with the notion that the medical application is in every respect similar to these wonder-exciting exhibitions, and the invalid is dismayed by the apprehended violence of shocks which he thinks his debilitated frame is totally unable to endure. A perusal of the following pages will, I hope, convince the reader that such fears are founded upon a totally mistaken notion of the nature of galvanism in proper hands as a medical agent.

21, *Connaught Square,*
March 24, 1855.

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PART I.

THE HISTORY OF ELECTRICITY.

CHAPTER I.

Electricity, which occupies so prominent a position in the present day, was wholly unknown to the ancients, and, indeed, its admission as a branch of physical science may be said to date from the beginning of the eighteenth century. The earliest account of electrical phenomena, of which we have any record, dates about 600 years before the Christian era. Thales, of Miletus, one of the Grecian sages, described a property possessed by amber, of being rendered capable, upon friction, of attracting feathers, bits of thread, straw, and such other light bodies. He imagined that the amber was endowed with some inherent living power, dormant under ordinary circumstances, but which was called into activity by friction; and that the amber, when so excited, emitted an invisible effluvium. This effluvium, the moment it was disengaged, immediately returned to the source from which it emanated, bringing back with it, however, such bodies as were not too heavy, and were, consequently, incapable of resisting its attractive force.

The next description of electrical attraction on record is found in a treatise on 'Stones,' by Theophrastus of Eresos, one of the most distinguished of the pupils of Aristotle. This eminent individual flourished about three hundred years after Thales. Pliny does not appear to have been particularly well conversant with the phenomena of electricity, for his knowledge seems hardly to have extended beyond that of Theophrastus; still, however, the ancient naturalists* were fully aware of the power of the shocks from the torpedo.

Eustathius, who lived in the fifth century, mentions some very remarkable facts: thus he states that Scribonius Largus, a physician who lived in the reign of the Emperor Tiberius, was in the habit of curing persons afflicted with the gout, by putting their feet into water in which there was a torpedo. This is the first instance on record of the application of electricity to the purposes of medicine. Eustathius also mentions that Wolimer, King of the Goths, could emit sparks from his body; but those facts seem to have fallen into oblivion during the lapse of ages, till Dr. Gilbert, of Colchester, brought them forth into light again. About two hundred years ago he published a work upon magnetism, in which he directed attention to several hitherto unobserved phenomena, which he attributed to electrical agency, and thus drew the notice of philosophers to the subject. He showed that many other substances, besides amber and tourmaline, possessed, when rubbed, the property of attracting light bodies.

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* Aristotle, Hist. Anim., lib. ii. and ix.; Pliny, Hist. Nat., lib. xxxii. Ælien, de Animal, Natura. lib. i.

The term electricity is derived from the Greek word ἤλεκτρον, which signifies amber, the substance in which the electrical properties were first observed. Consequently it took precedence in giving a name to the newly-discovered science.

The reasoning of Gilbert, however, was in very many instances erroneous; still his parallel between the magnetical and electrical attractions being very ingenious, must have proved, in his day, interesting and instructive. After Gilbert there seems to have been an interval of about sixty years, during which little or no progress appears to have been made. Mr. Boyle is the next inquirer whose investigations deserve any mention. But though he devoted much time to the subject, and by repeating the former experiments confirmed their results, yet he did little beyond adding a few more to the existing number of electrics. His theory of electrical attraction was precisely the same as that of Thales before mentioned. He supposed that the electric body emitted a sort of glutinous effluvium, which, upon its egress, laid hold of or became entangled in the pores of the bodies which it met with in its progress, and carried them back with it upon its return to the body from which it originally emanated. The electricians of the time advocated this theory, and experiments in proof were made, an account of which will be found in 'The Philosophical Transactions.' But the most important advances in the science, at this time, were due to Otto Guericke of Magdeburg, the celebrated discoverer of the air-pump.

The apparatus used in electrical experiments was at first extremely simple. A glass rod, or a stick of sulphur or resin rubbed with the hand, or a piece of woollen cloth, was the first means of exciting electricity, and, until the seventeenth century, little more of complexity obtained. The electricity thus excited was of course very small. Otto Guericke, before mentioned, was the first to contrive a proper electrical machine. Sir Isaac Newton may be the next to be noticed as being the first to observe that glass, when excited, attracted light bodies, not only to the rubbed surface but also to the opposite one.

From this period but little progress was made for nearly forty years. The experimenters had no system, nor did they at all understand the principles upon which the effect they produced really depended. So stood the subject of electricity till Mr. Stephen Grey, a pensioner in the Charter-house, first opened the way, in 1730, to a knowledge of the true foundations of the science. He discovered the distinctions between what are termed *conductors* and *non*-conductors. The discovery of this important distinction was the result of pure accident, and occurred to him whilst engaged in an attempt to communicate electricity to a line, or in other words to electrify a line suspended by threads. The attention of electricians being thus directed to these differences in properties, it was observed that the bodies known as electrics,—that is capable, like glass, of being excited by friction—were *non-*, or at least *bad*, conductors; while those which were seemingly incapable of electrical excitement—as metals, &c.—were found to be *excellent* conductors.* It is upon these two opposite qualities that a tolerably large proportion of the electrical phenomena, rendered evident to our senses, depend. It may, therefore, be as well, before proceeding further, to explain these distinctions.

It has been already observed that if certain bodies, as amber, glass, sealing-wax, &c., were rubbed, either by the hand or by certain substances, peculiar phenomena were developed. If, for instance, a common phial be rubbed on the sleeve of a coat, or with a dry silk pocket-handkerchief, and then be immediately held over slips of tissue paper, feathers, or pith-balls, these will jump up and attach themselves to the excited surface, to which they will remain attached for a short time, when they spontaneously drop off. But if a cylinder of brass or copper be treated precisely in the same manner, it will manifest none of the foregoing properties. Glass, then, and the analogous substances, were called "electrics," because, when excited by friction, they exhibited these electrical phenomena. But the metals being incapable of such excitement, were therefore called "non-electrics." Now, it must be quite evident to the least reflection, that the *electric* owes these special properties to its *non-conducting* power, whereas the *non-electric* owes its special properties to its conducting powers.

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* By these terms are to be understood bodies which respectively refuse or allow transit to the electric fluid. If the electricity be directed against a plate of glass, it will be shivered into atoms; but if directed to a metallic wire, it will run along the wire, whatever its length. It is upon this latter property—conduction—that lightning conductors are used to protect buildings, ships, &c., from destruction by lightning.

By conduction is to be understood an inherent capability of giving a ready transit to the electric principle, whatever this may be, and transmitting it from particle to particle, till it has passed through the whole length, from one extremity to the other, of the conducting body. But the properties of the electric or non-conductor, are derived from a directly opposite capability; that is to say, it refuses, or rather will not give passage to, the electric fluid, but forcibly resists all transmission. We need only direct the attention to the railway telegraph for an exemplification of these principles. The copper wires are powerful conductors, and carry the electric fluid, with almost inconceivable rapidity, along their whole length. The other principle is exemplified by the coating of these wires along their entire extent, with an electric or non-conductor. The electric fluid, as it passes along, would be exposed, during its transit, to the influence of conducting or attracting agencies—for instance, atmospheric vapours or moisture; but these agencies are rendered wholly inoperative, and, therefore, paralysed, by the sheathing with an electric or *non-conductor*, as is the coating of wax or resins, or whatever it may be. About the period a little before alluded to, M. du Fay, the intendant of the French king's gardens, hit upon the grand discovery, that there were two distinct kinds of electricity, the one called into activity by the excitement of glass, which was, therefore, named the "*vitreous*," the other by that of amber and resin, and from this latter derivation he named it "*resinous*."

During the experiments of this period, a *then* very singular and wonderful phenomenon was observed, which had the effect of completely riveting the attention of philosophers. It was found that, under peculiar circumstances, sparks could be elicited from the human body. Mr. Grey, having suspended a boy, by means of hair lines, in the horizontal position, communicated electricity to him, while so suspended, by means of an excited glass tube. Upon approaching a conductor, sparks were given out from all parts of the body. This phenomenon, readily intelligible upon the principle of conductors and nonductors already explained, was supposed at the time to be owing to some mysterious connexion between the electric effluvium, as it was called, and the vital principle. The explanation is very simple—the lad was insulated by the medium of suspension, hair being a non-conductor. Consequently, he became charged with electricity similarly to what is now done by means of a stool with glass legs. The human body, and, indeed, that of all animals, is naturally a conductor, in consequence of its fluids. But when insulated the conducting power is suspended, and an accumulation of electricity is the consequence. On approaching the finger of another person, not insulated, a spark is drawn or emitted, as from the prime conductor of an electrical machine when in action.

About the middle of the eighteenth century, the subject of electricity attracted the attention of the Germans, and the investigation of electrical phenomena was zealously pursued. Their experiments excited a good deal of interest, but none so much as the setting on fire various inflammable substances by means of the electric influence or spark. Dr. Ludolph, of Berlin, was the first to ignite gunpowder, spirits of wine, &c., by emitting electric sparks from an electrified person insulated by standing on a cake of resin.

It was not, however, till the beginning of 1746, that the important discovery of the Leyden jar was made, and gave a new impulse to the development of electrical science. Professor Muschenbroeck, observing that electrified bodies exposed to the air speedily lost or parted with their electricity, conceived the idea of surrounding or coating them with non-conductors. He hoped by these means, to secure their electrified condition, and, indeed, to accumulate and concentrate the electric powers. With this view he attempted to electrify water contained in a glass bottle; but the experiment failed, or at least was not attended with any satisfactory results, owing to the omitting of a conducting medium upon the outside surface of the glass.

M. Cuneus, while repeating the experiment, and holding the bottle in one hand, attempted with the other to disengage the wire communicating with the prime conductor of a powerful machine. An immediate and smart shock, through both his arms, was the almost instantaneous consequence. Muschenbroeck repeated this experiment; and in a letter to Reaumur, describing the results, states, "that he felt himself struck in his arms, shoulders, and breast, so that he lost his breath, and was two days before he recovered from the blow and the terror;" adding "that he would not take a second shock for the kingdom of France."

The shocks, given by the small phials at first employed, notwithstanding their feebleness, caused so much nervous apprehension, and produced, as we are told, such distressing effects, as to terrify persons from making the trial, yet, within a few years after, we find Dr. Franklin experimenting with jars capable each of containing six gallons. With these he gave such violent shocks as no one in the present day would venture to attempt. Thus in a letter, dated at Philadelphia in 1755, he gives an account of knocking down six men with two of these large jars, though not fully charged.*

The wonderful power and effects of the electric shocks were well calculated to attract the attention of the public; and imagination, ever fertile, set no bounds to its medical powers. But its indiscriminate application to the treatment of diseases of the most opposite nature, without any laws or any fixed principles as a guide—without any perception or knowledge even of the effects produced by currents flowing in opposite directions—caused electricity to sink into empiricism; and a remedial agent of sterling value and transcendent powers gradually fell into oblivion and disuse. Nor was this the only cause of its downfall; the very cumbersome and expensive apparatus in use for its excitation, in a degree of even moderate tension, contributed not a little to bring it into disrepute.

But a new era was about to break forth; and the beginning of the present century was destined to behold the study of electro-physiology resume, not merely its former rank, but a far greater degree of vigour. We are, indeed, greatly indebted to the laborious researches of Matteucci, among other philosophers, for the great progress since made in this department of science; and I fully agree in the observation of Mr. Noad:—"It is much to be desired that the knowledge with which we have been furnished by the beautiful electro-physiological researches of Matteucci should receive a much more extended practical application in this country than it hitherto has had."

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* In 1778, Cavallo published his celebrated work, which passed through six editions. He stated that electricity is a most useful agent, but unfortunately, through misapplication, frequently failed to do good. Every one was resorting to electricity for the cure of disease, consequently repeated failures brought it into disrepute.

The application and effects of electricity will be much more easy of explanation, and much more readily comprehended, by premising a concise description of its sources and the different methods of exciting it.

SOURCES OF ELECTRICITY.

There are five sources from whence electricity may be derived, namely, friction, and hence called frictional electricity; chemical action, or galvanic, or voltaic electricity; certain arrangements with induced magnets* called electro-magnetism, or electro-magnetic electricity; a peculiar inherent power in some animals, as the torpedo, gymnotus, electrical eel, &c.—hence animal electricity; and lastly, disturbances of temperature, and so named thermo-electricity.

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* We are indebted to Professor Faraday for this mode of exciting electricity. As a brief generalization of this discovery, it may be stated, that whenever an electric current traverses a wire, it excites a current in an opposite direction in a second wire held parallel to it. These induced or secondary currents are but of momentary duration, appearing only at the instant the primary or inducing current either effects its passage, or ceases to pass through the wire.

FRICTIONAL ELECTRICITY.

The first effectual mode of exciting frictional electricity was the electrical machine and the Leyden jar. The value of the machine consists principally in affording an easy and simple means of performing friction, and in the means of collecting and accumulating the electric essence whatever this may be.* There are two kinds of electrical machines—the cylindrical and the plate. As secondary parts, may be named the prime conductor, the Leyden jar, and the discharger.

The cylindrical machine consists of a hollow cylinder of glass supported by brass bearings or trunnions which are in turn supported by upright pieces of wood fitted into a rectangular base. The bearings admit of being rotated, and being firmly fixed to the cylinder, carry it round, rotating it, as it were, upon its axis. The rubber, which consists of a hair cushion covered with leather, over which is placed a flap of black silk, is mounted, for the purpose of insulation,† upon a glass support or upright post, when the exhibition of negative electricity is required. The rubber is in contact with the cylinder, and is furnished with an adjusting-screw, by which it can be approximated to or removed from the cylinder according as the object may be an increase or decrease in the amount of friction. The cushion is connected, by means of a chain, with the ground whence the supply of electricity is drawn.

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* The conventional theory generally adopted at present is, that electricity is a compound imponderable form of matter, consisting of two elements, denominated the positive and the negative electric fluids. These elements, when separated, exhibit a similarity of phenomena, but, when united, so completely neutralise each other, that, in effect, the existence of the neutral fluids cannot be detected, except by separating the compound into its constituent elements.

† A body is said to be insulated when supported by a non-conductor in such a way that the electricity cannot be carried off. A person standing upon a stool with glass feet is said to be insulated.

The prime conductor consists of a long, hollow, metallic cylinder of brass or tin, supported by a glass upright rod or foot. One extremity of the conductor is fitted with a number of metallic points something like a toasting-fork. These points are placed opposite and close to the revolving cylinder of glass, and draw from it the acquired electricity, while the flap of silk attached to the rubber prevents its dissipation or dispersion from the surface of the glass before it reaches the points.

Plate machines are much used on account of their being capable of giving rise to a much greater quantity of electricity, and for which this construction of instrument is much more adapted. It consists of a circular plate of glass about a quarter of an inch thick. It is perforated in the centre by a plug or axis for its support, so that when supported it has a vertical position. These supports consist of two cheeks of baked wood: on the upper and lower parts of these cheeks firm cushions are fixed so as to press against both surfaces of the glass plate. To these cushions are attached flaps of oiled silk, which prevent the escape of the electricity before it arrives at the collecting-points of the prime conductor.

The theory of the machine is as follows :—By turning the handle of the cylinder the electricity in the rubber is decomposed, the positive adhering to the glass, and the negative to the rubber, which would, therefore, if insulated, after a few revolutions, develop no more free positive electricity. To obviate this, a communication is made, by means of the chain, between the rubber and the earth. By these means the supply of positive electricity is kept up, and the negative state neutralized. The positive electric portions of the glass coming, during its revolutions, opposite to the collecting-points on the conductor, act powerfully by induction on the natural electricities of the conductor, attracting the negative, which being accumulated in a state of tension at the points, darts off towards the cylinder to meet the positive fluid, and so restore the neutral compound. The conductor is therefore powerfully positive.

The terms positive and negative are used to distinguish two different forms of excitement; and although they originated from theoretical views of the nature of electrical disturbance, not now recognised, they are, on the whole, less objectionable than the other terms, and have therefore been retained. Positive electricity is produced upon polished glass when rubbed with a woollen cloth; and negative by similar friction applied to a stick of sealing-wax. The one kind cannot be produced without the other, and when two substances excite electricity by mutual friction, the one is positive and the other negative.

The Leyden jar affords us the means of increasing the intensity of the electric power. It consists of a jar or phial, a portion of both the inside and outside of which is coated to about two-thirds or more of their height with a non-electric or conductor. Tinfoil is generally used for this purpose. The mouth of the jar is fitted with a wooden plug, usually cemented in by sealing-wax. The plug is perforated by a metallic rod, generally brass. This rod has a large round metallic knob on the top outside, while, by its inner extremity, it communicates with the interior metallic coating of the jar by means of a piece of wire or small chain. It is evident then that the jar consists of an electric or non-conductor, enclosed between two non-electrics or conductors. If the metallic knob be brought near to the prime-conductor of an electrical machine in action, or, indeed, any excited body, a spark is seen to pass from the conductor to the knob of the rod which passes into the jar, and the action is attended with a kind of crackling noise. The jar, so placed, soon becomes charged with electricity. The jar, when charged, remains so—no discharging influences being permitted to act—for some time. Indeed, so long as there is no communication, by means of a conductor, between the two coatings, the jar will remain charged.

The discharge is effected by means of what is named a *universal discharger*. It consists of two metallic rods, each surmounted at one extremity by a metallic knob. They are united at the other extremity by means of a hinge joint, by which the opposite extremities may be made to converge or diverge at pleasure. They are fitted to a glass handle or non-conductor. The discharge is thus effected. The operator, having separated the knobs to a convenient distance, and holding the discharger by the glass handle, places one of the knobs upon the outside coating, and the other upon the ball of the rod which communicates with the inside of the jar. Immediately this is effected, a vivid spark is seen, and at the moment a loud noise is heard, and the jar is discharged.

The theory of the jar is easily understood upon the principle of induction. The inside is rendered *positive* by the charged conductors of the machine, and hence by the law of induction the outside becomes *negative*. The discharge by the conductor merely restores the equilibrium of electricity between the two surfaces, or the inside and outside of the jar. A series of these standing in the compartments of a box (like decanters in the compartments of a wine-cooler), and united by means of a conductor or metallic chain, forms the electrical battery, the powers of which are most surprising.

Batteries of this description may be constructed of such wonderful powers as not only to destroy instantaneously the strongest animals, but to fuse metals, and tear asunder the most refractory substances.

If an ordinary Leyden jar be charged, as already stated, it may be taken in the hand and carried about, provided the outside coating only be touched; but if the knob of the perforating rod be touched at the same time that the outside coating is touched with the other hand, the party will experience a violent shock, the intensity and violence of which will be in proportion to the charge. The simple explanation is, that the individual becomes a sort of universal discharger, and by restoring equilibrium between the electricity of the two surfaces, the external and internal, produces the similarity of effect.

But the jar is not fitted for medical purposes, because such large quantities of electric fluid, and of such great intensity, brought at once into action, produce in the human body concussions so violent that they cannot be sustained without serious injury. Indeed, as already noticed, electric shocks may be rendered so powerful as to cause instant death, and the appearances exhibited by bodies after a violent death from this cause are precisely similar to those presented by the bodies of animals killed by lightning. In both cases they undergo rapid putrefaction, and the blood does not coagulate.

GALVANIC OR VOLTAIC ELECTRICITY.

Galvanic or Voltaic electricity, or rather its discovery, was the result of accident, during some experiments, which Galvani, a professor of anatomy at Bologna, was carrying on in 1791. One account states that the wife of Galvani being ill with consumption, was advised to take, as a more nutritive kind of food, soup made of frogs. A pupil of Galvani's having observed that the limbs of one of the frogs became convulsed when touched with a knife that was near to an electric machine, drew the attention of the professor to the circumstance. Galvani himself, however, in a work which he published at Bologna in 1791 for the Institute of Science,* relates, that a pupil of his was making some experiments with an electric machine, while several frogs that had been recently killed and skinned were lying about on a table in the laboratory, close to an electrical machine. While the machine was in action he chanced to touch a bare nerve in the leg of one of the frogs with the blade of a knife which he held in his hand, when the whole limb was instantly thrown into violent convulsions. Galvani, after much inquiry, discovered that the effect was quite independent of the electrical machine; and that similar results might be equally well obtained by establishing a metallic communication between the outside and the crural nerve. It is, however, to Professor Volta of Pavia, that we are more especially indebted for the construction of the first Voltaic pile. It was he also who first discovered and explained that the electric excitation was the result of the contact of two distinct metals, by the meeting of which the natural electricity was decomposed; the positive passing to one of the metals and the negative to the other, while the muscle of the frog acted merely as a conductor. In support of these views he instanced the peculiar sensation caused by the contact of a piece of silver, with a piece of lead or one of zinc, when the tongue* was placed between them; a fact which had been previously noticed by M. Sulzer of Berlin in 1762. The results of Volta's most important experiments were published by him, in the Philosophical Transactions in 1800.

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* Aloysii Galvani de viribus electricitatis in motu musculari commentarius.

It has been already stated that galvanism was first discovered by Galvani (hence the name galvanism) and that Volta was the first to construct the pile. It may now be as well to give some little notion of galvanic or voltaic arrangements. Conductors of electricity are divisible into two kinds—*perfect* and *imperfect*. The more *perfect* conductors are the metals, charcoal, plumbago, the mineral acids and saline solutions. The *imperfect* are water, alcohol, ether, sulphur, oils, resins, the oxides of the metals and the compounds of chlorine. The most simple arrangement is termed a simple galvanic circle. If a piece of silver—a shilling or half-crown piece, for instance—and a disk of zinc be applied to the tongue without contact of the metals, no peculiar sensation results; but if they be approximated so that they may touch in a part of the circumference whilst the tongue remains interposed between the other portions of their surfaces, the moment this arrangement is completed, a peculiar tingling metallic taste is felt, and a simple galvanic circle formed, consisting of two perfect conductors—the metals, and one imperfect—the tongue or the saliva.

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* Schoenbein. Ueber einige mittelbare physiologische Wirkungen der atmosphärischen Electricität; Henle und Pfeufers Zeitschrift, 1851.

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Volta's first pile consisted of a series of two perfect, with an intermediate imperfect conductor, piled up on each other so as to form a vertical column. Thus if circular plates of zinc and silver or copper be placed upon each other, with a circular piece of cloth moistened with water or a solution of common salt, so as to form a vertical pile of from fifty to sixty plates, we shall have Volta's first pile. If the upper and lower end of the pile be touched with metallic rods, one in each hand, which should be previously moistened, a smart shock will be felt. The wires from the extremities of the pile are found to produce—that from the zinc positive or vitreous electricity, that from the copper, negative or resinous.

But considerable improvements have been made in these arrangements. Thus, earthenware or gutta-percha troughs have been made, and these again divided into compartments or cells. Into these cells, filled with the necessary fluid, the metallic plates are immersed, and the communications between the plates kept up by connecting wires. The advantages of such arrangements are, that both surfaces of the plates may be exposed to the action of the fluid; and they can be lifted out when the galvanic action is not required. It has been found that the power is increased more than one-half by a copper plate being placed on each side of a zinc plate in each cell, so as to expose each surface of the zinc to one of copper. The separate troughs are united by connecting the zinc end of the one with the copper end of the other by means of copper-foil. A series of these constitutes a *galvanic battery.*

The fluid must be such as will exert a chemical agency upon one of the metals, and the effect is in general proportional to the rapidity with which the more oxidizable metal is acted upon by the fluid. The best fluid, according to Mr. Children, consists of three parts of fuming nitrous acid, one of sulphuric acid, with thirty of water. By a powerful battery, the metals—even the most refractory—are not only ignited and fused, but even volatilized. Gold, subjected to such influence, emits, during its combustion, a vivid white light, approaching to blue. Copper presents somewhat similar phenomena; silver gives a vivid green; lead a bluish purple; tin like gold; and zinc a bluish flame tinged with red.

Compound bodies are readily decomposed and their elements separated by the galvanic agency. Oxygen and the acid accumulate round the positive pole; but hydrogen, the alkalies, earths, and metals attach themselves to the negative. The most astonishing results, however, were obtained by Sir H. Davy. He suspected that the elements of compound bodies attracted each other in consequence of their being in opposite states of electricity;* and hence that, if similarly electrified, the elements instead of attracting would repel each other; or in other words that attraction and repulsion depended upon the nature of the electrical states; and that compounds which had hitherto resisted the ordinary methods of decomposition might thus be resolved and their elements separated. Acting upon these views he undertook the decomposition of the alkalies; and his attempts were attended with a success as brilliant in history, as important in philosophical result. He concluded that if potash, as suspected, was a compound of oxygen with a combustible base, when exposed to the agency of opposite electricities, the oxygen would be attracted by the positive while it was repelled by the negative pole; and that the direct reverse would occur with respect to the base, which would appear at the negative pole.

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* The laws of electrical attraction and repulsion are observed in the effects of this power upon bodies submitted to its action; for example, if the two poles of a galvanic battery be placed in water, the negative electrical component of the water, namely, the oxygen, is given off at the positive pole, and the positive constituent, the hydrogen, at the negative. If the compounds of the metals with oxygen, that is, the metallic oxides, be exposed to the decomposing power of the electric current, the elements will be separated, the oxygen being given off at the positive pole, and the metallic base at the negative. If the body to be decomposed be a salt, a compound of an acid with an oxide, the acid will appear at the positive, and the oxide at the negative pole.

On attempting by experiment to verify these views, he at first failed, because he employed an aqueous solution of the alkali; and thus a considerable portion of the electrical energy was expended in the mere decomposition of the water. In his second attempt, however, he proved more successful. The alkali was fused by being heated in a dish of platinum, and the outer surface of the dish, immediately under the alkali, was connected with the positive pole of a battery consisting of one hundred pairs of plates, each plate being six inches square. The potassa itself was touched with a platinum wire connected with the negative pole. Immediately a brilliant and intense light appeared at the negative wire, and a flame produced, evidently owing to the combustion of some inflammable base. The potassium* the moment it was separated from the oxygen took fire, and hence in this experiment it could not be collected; still, however, satisfactory evidence of the decomposition of the potassa was thus obtained.

The chief difficulty in such experiments arises from the circumstance, that potassa in its *dry* state is a complete *non-conductor* of electricity. It may, however, be rendered a *conductor* by the slightest moisture, such as merely breathing on it. In this state it is readily fused and decomposed by the agency of strong electrical powers. The mode of proceeding is as follows:—From about 70 to 80 grains of potassa, moistened by breathing on it, are to be placed in an insulated platinum dish. This dish should be connected with the opposite ends or poles of a galvanic battery consisting of not less than 100 pairs of plates, each plate six inches square, in the manner already described. On establishing the connection, the potassa immediately fuses when it is in contact with the platinum wire. A brisk effervescence speedily succeeds, and a gas escapes at the positive end which may be easily collected and proved to be oxygen. No gas escapes or is disengaged at the negative wire; but small globules appear, having a high degree of metallic lustre, and much resembling quicksilver in appearance. Some of these globules explode and burn with a bright light, but a whitish film coats others, and this tarnish on the outside protects the internal portion from the action of the surrounding medium,* and so prevents further change. Thus, by the agency of galvanism, potassa is decomposed and resolved into its two elementary constituents, namely, oxygen and a peculiar base possessing most of the properties assigned, as the characteristics of the metals. This base, like all combustibles, is repelled by positively electrified surfaces, and attracted by those in the opposite or negative condition, and consequently its own natural electrical state must be *positive*. Hence it is that the constituent elements of the potassa, namely, the oxygen and the potassium, when similarly electrified, separate and seek the opposite poles of the battery.

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* The metallic base, or radical of potash, is so named.

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* The medium here meant is the atmospheric air. When used, this term medium means a body which surrounds, or intervenes, and capable of exerting any action upon other bodies.

Bodies, therefore, that are similarly electrified repel, while those in opposite electrical conditions attract, each other. Hence, by means of this agent, we can modify chemical attraction; and, by varying or changing the electrical conditions, either exalt the intensity, or wholly subvert chemical combination. The elements of all the compounds hitherto examined have been found to be in opposite states of electricity. Copper and zinc are oppositely electrified in respect to each other; so are gold and mercury; sulphur and the metals, and the acids and the alkalies the same: and hence it is that these bodies mutually attract each other with intensities in some measure proportioned to their electrical conditions. By bringing bodies, having naturally an attraction for each other, into similar states of electricity, the tendency to combination is weakened, suspended, or wholly suppressed, and even a repulsive agency may be generated. For instance, zinc and iron, when both are rendered negative, cannot be made, while in this state, to unite with oxygen—a principle with which they have a strong tendency to combine.[*] Davy thinks it probable that bodies, even after their union, retain their peculiar or natural electricities; as thus: if oxygen predominates over the combustible, the compound will be *negative*, as is observed in certain of the metallic oxides; on the other hand, if the combustible is the predominant principle, the electricity of the compound will be *positive*. But when the elements precisely neutralise each other, bodies that before exhibited electrical indications lose these properties, or, in other words, they are neutralised or suspended during the combination.

The phenomena exhibited by frictional and by voltaic electricity would seem to indicate fluids or powers widely differing[†] from each other in their nature. But it should

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[*] It will thus be rendered intelligible how iron galvanised resists its tendency to unite with oxygen, or to *rust;* for rust is nothing more than a hydrate of the peroxide of iron.

[†] The difference between frictional and voltaic electricity[*] is as follows:—the first produces its effects by a comparatively small quantity of electricity, insulated in a high state of tension, having remarkable attractive and repulsive energies, and power to force its way through obstructing media; the latter is more intimately associated with other bodies, enormous in quantity, but rarely attaining a high state of tension, and exhibiting its effects while flowing in a continuous stream.

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[*] Experiments were made at the School of Medicine in Paris on the treatment of disease by galvanism, and the Commission who reported on it found reason to conclude that the effects of the voltaic battery penetrate and affect the nervous and muscular structures more deeply than ordinary electric machines.—*Becquerel*, vol. i.

be observed that the different conditions in which the electricities of the electrical machine and of the voltaic pile are excited cause a difference in the phenomena which each exhibits. It is by no means easy to make an arrangement with frictional electricity by which chemical decomposition could be exhibited; nor, on the other hand, could the electric spark from a galvanic battery be readily made to force its way through even a very small expanse of air. The experiments, however, of Sir Humphry Davy and of Dr. Faraday have left no doubt whatever of the capability of frictional electricity to effect chemical decomposition. Mr. Crosse, with a water-battery of two hundred cells,* has succeeded in evolving voltaic electricity of sufficient tension to force a passage through a small space of air.

ELECTRO-MAGNETISM.

In the year 1819, Professor Oersted, of Copenhagen, observed, that when a magnetic needle was brought near the connecting medium of a closed voltaic circle, the needle was immediately deflected from its ordinary position, and assumed a new one. This discovery led to the construction of a new apparatus—the electro-magnetic or magneto-electric machine; an instrument by which a rapid and continuous succession of sparks can be elicited from a permanent magnet.* This instrument was the invention of M. Hipolyte Pixii, of Paris, and was made known at the meeting of the Academie des Sciences in the September of 1830. A description of it will be found in the "Annales de Chemie,' for July, 1832. With this machine, furnished with a coil of wire 3,000 feet in length, sparks were elicited and powerful shocks given. A Leyden jar was feebly charged, and water was decomposed.

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* There are many modifications of arrangement for exciting voltaic or galvanic electricity; and the batteries are distinguished by the names of their inventors or those who use them. Such for instance are Becquerel's, Groves's, Daniel's, Bunzen's, and Smee's. The last, from its simplicity, and the ease with which its action can be applied, has, in general, obtained the preference.

Since this period, numerous forms of electro-magnetic machines have been invented, and adopted for medical purposes, but most of them upon erroneous principles. They are so constructed as to give shocks of great intensity, which excite severe irritation in the nervous system, and thus greatly injure the human body. In fact, these machines entirely fail in two essential requisites, viz., in producing a sufficient quantity of electric fluid, and in the power of passing the current in one direction only. This will be made apparent by a short description.

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* There are found certain mineralized bodies which are magnetic; that is, capable of exerting the well-known influence of the magnet or loadstone. These, as they are met with in nature, constitute the natural magnet. A piece of hard steel may be rendered magnetic, and will then exhibit all the phenomena and properties of the natural loadstone, and so becomes a permanent magnet. An electro-magnet may be formed by surrounding a bar of soft iron with covered copper wire, and becomes magnetic by passing an electric current through the coil of copper wire, but the magnetic power so excited is not permanent. An electro-magnet, of the horse-shoe shape, half an inch in diameter, and five in length, with three or four spirals of covered wire of the thickness of bell-wire twisted round each limb in the same direction, will, if excited by only a single pair of plates four inches square, lift a weight of several pounds.

At the Great Exhibition, an electro-magnet was shown which could lift one ton weight; and others of still larger size have been made capable of lifting a weight of several tons.

A coil of about 30 feet long of thick insulated copper wire is wound round upon a small bobbin; over this is wound about 1,500 feet of thin copper wire, also insulated. On sending the current from the battery through the inner coil, the electricity of the external one is set in motion by induction. On breaking the battery contact, the current immediately ceases in the thick wire; and the electricity in the thin one, now freed from the influence of the disturbing cause, returns to its primitive condition, and at the same time gives a shock.

Now, here it will be evident that the current produced in the thin wire is not derived from the battery, and that it passes in one direction when contact is made; but in the opposite when the contact is broken. A bundle of iron wires, placed in the hollow axis of the bobbin, by becoming a series of temporary magnets, increases the brilliancy of the sparks and the intensity of the shocks. The instrument which I employ, called by the inventors the "electro-galvanic machine," differs from those just noticed in this, that it derives its electricity from the battery, the current being sent through one coil of thick wire, in order to give it sufficient intensity to overcome the resistance which it meets with in passing through the human body. It has further the advantages, that it gives a continuous succession of shocks; its management is very easy and very simple; and its action may be directed without the slightest danger to any part of the body. The intensity of the current can be immediately increased or diminished at pleasure; nor is its use attended with that disagreeable burning feeling of heat so often complained of. The chemical effects produced in the parts to which its electricity is applied are very considerable.

ANIMAL ELECTRICITY.

Certain fishes, as the gymnotus, the torpedo, and some others,* have the power of generating electricity. This seems to have been given to them principally as a means of self-defence, for it is entirely dependent on the will of the animal. The torpedo is found in Europe; the gymnotus and the others are confined to the tropics. The exercise of this electric capability seems to be closely connected with the nervous system, for very great exhaustion attends its frequent exertion.

The electrical organs of the torpedo are situated on each side of the head, and consist of a great number of hexagonal prisms, their bases pointing to one side of the fish and their apices to the other. The number and size of the nerves distributed to these organs must, on reflection, appear in proportion to their size as extraordinary as the effects they produce. The power of giving shocks depends entirely upon the nerves of the fish, for the heart may be removed without in the least impairing this power. But the moment the nerves are divided the electrical power is lost. Professor Matteucci, in the observations which he submitted to the Royal Society, states, "We have every reason to conclude that the electric organ of the torpedo, and of all the electric fishes, is composed of a great number of elementary organs, and that the elementary organ is nothing else but a nervous fibril in contact with a small cell filled with albumen. It is in studying the production of electricity in the different electric fishes, together with the distribution of nervous filaments in their electric organs, that we arrive at a better understanding of this relation between nervous force and electricity. Thus we see in the torpedo and gymnotus, the two electric fishes best known, physically and anatomically, that the nervous filament always ramifies in the electric organs of these fishes perpendicularly to the axis of the prisms of these organs. Besides which, we know that the extremities or poles of the electric organs in these two fishes are situated at the extremities of the prisms; in effect, in the torpedo these poles are the ventral and dorsal surface, while in the gymnotus the poles are at the head and tail of the animal." The torpedo, on being touched, causes a sort of benumbed feeling, and by repeated contact gives a series of electric shocks. Dr. John Davy obtained very satisfactory electro-chemical results.

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* The following have this extraordinary power: the tetraodon, silurus, rhinobatus, and trichiurus electricus.

The gymnotus, in appearance, resembles an eel; the body is smooth, devoid of scales, and often four or five feet long. The electrical organs of the fish are situated on each side of the spine from the head to the tail, and in some degree similar to a voltaic battery. The whole power of this living battery is exerted when the connexion is made between the head and the tail. On putting a small living fish into water in which there is a gymnotus, the latter forms itself into a circle, in which it encloses the fish, and thus sends a discharge through the water, and so instantly stuns its prey. If the hand is held in the water while the charge is transmitted, a shock is felt, but not so strong as when the fish is touched at its two ends.

Humboldt gives the following interesting account in the "Edinburgh Review:"—The Indians entertain such a dread of the gymnotus, and show so much reluctance to approach it when alive and active, that he found extreme difficulty in procuring a few to serve as the subjects of experiment. For this express purpose he stopped some days on his journey across the Llanos to the river Apuré, at the small town of Calaboze, in the neighbourhood of which he was informed they were very numerous. But though his landlord took the utmost pains to gratify his wish, he was constantly unsuccessful. At last he determined to proceed himself to the spot, and was conducted to a piece of shallow water, stagnant and muddy, but of the temperature of 79°, surrounded by a rich vegetation of the great Indian fig-trees and the odoriferous sensitive plants. Here he soon witnessed a spectacle of the most novel and extraordinary kind. About thirty horses and mules were quickly collected from the adjacent savannahs, where they run half wild; these the Indians drove into the marsh. The gymnoti, roused from their slumber by the noise and tumult, mount near the surface, and, swimming like so many livid water-serpents, briskly pursue the intruders, and, gliding under their bellies, discharge through them the most violent and repeated shocks. The horses, convulsed and terrified, their manes erect, and their eyes starting with pain and anguish, make unavailing struggles to escape. In less than five minutes two of them sunk under the water and were drowned. Victory seemed to declare for the eels; but their activity now began to relax: fatigued by such expense of nervous energy, they shot their electric discharges with less frequency and effect. The surviving horses gradually recovered from the shock, and became more composed and vigorous. In a quarter of an hour the gymnoti finally retired from the contest, and in such a state of languor and complete exhaustion, that they were easily drawn on shore by the help of small harpoons fixed on cords."

THERMO-ELECTRICITY.

Metallic bodies are capable of electric manifestations when a disturbance in the equilibrium of temperature has been effected. This was originally observed by M. Seebeck, of Berlin; and he announced this interesting fact in the year 1821. The essential conditions are, that the extremities should be in opposite states as relates to temperature. Hence the name "Thermo-Electricity."

If bars of two different metals, as, for example, copper and bismuth, be soldered together, an electric current becomes developed on heating the point of junction of the two metals with a spirit-lamp. The quantity of electricity excited is, to a certain point, proportionate to the different degrees of temperature communicated to different parts of the same metallic bar, and does not depend on the absolute heat. Thus the application of ice will produce an electric current as well as the application of heat; and by applying ice to one corner and the flame of a spirit-lamp to the other at the same time, the effect is greatly increased.

M. Mellori and Professor Forbes have made great use of thermo-electricity in their investigations into the nature of heat, as it affords the most sensitive means of detecting variations of temperature. The apparatus of Professor Forbes is called a "thermo-electric battery;" and so sensitive are its indications, that the mere placing of the hand near the end of the battery causes a deflection of several degrees.

CHAPTER II.

ELECTRO-PHYSIOLOGY.

The description given in the foregoing pages of the construction of the electro-magnetic coils hitherto in general use, is quite sufficient to show the little attention so really important a subject has attracted in this country. The employment of electricity as a therapeutical agent in the treatment of disease is founded upon no rational or scientific principles, but upon merely a somewhat vague and crude notion of a sort of inherent power or capability of removing or at least relieving the sufferings of the patient. Thus no knowledge of the laws which direct and govern the action of this agent has been displayed, nor any definite idea of the results to be expected or derived from its application entertained. Is it then to be wondered at that a remedy applied in such total ignorance of its powers and operations should have failed under such management? or that those who had resorted to it, as their last hope, when, perhaps, all other means had been tried in vain, should be doomed to disappointment and vexation? But indeed it is no way surprising that persons of narrow minds and meagre judgment should at once ridicule and condemn the efforts of those who aim at enlarging the sphere of the medical art by means of the knowledge to be derived from the collateral sciences. Many, indeed, have been thus deterred from the study, and from cultivating a knowledge of this wonderful and all-pervading principle; and, in consequence, its application to medicine has been left to ignorance and empiricism.

Professor Galvani published in the year 1791, in his celebrated commentary,* an account of the experiments which he had made on the contractions excited in the muscles of frogs, and thus laid the foundation of that science which bears his name. According to the views of Galvani, the muscles contain the animal electricity; they resemble, he says, a Leyden jar, their outer surface being that which is charged with the negative; the inner with the positive electricity. The nerve performs the part of a conductor, and serves, with the blood-vessels, to supply the electricity for charging this jar. Volta, of whom mention has been already made, repeated the experiments detailed by Galvani, and he came to the conclusion that the muscular contractions were produced by the irritation of the nerves, and that this irritation by the metallic arc† was the result of an electric current excited by that arc.

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* De viribus electricitatis in motu musculari.

† A metallic arc is the means by which a galvanic circuit is completed; each end being composed of a different metal.

In the year 1796 Volta made his immortal discovery of the pile, which caused all opposition on the part of Galvani to fall into oblivion, and for twenty-three years no further mention was made of animal electricity.

In 1827, Nobili demonstrated the electro-magnetic action developed by the current of the frog. It was reserved, however, for Matteucci of Pisa to fix the attention of philosophers upon this subject. He proved beyond all question or doubt that electric currents pervade the muscles of a living animal, and that a current of positive electricity is constantly circulating and moving from the interior of the muscle to its outer surface.

Matteucci, by a great number of experiments, has further shown that the strength of this current is weakened by the intensity of the summer heat, and indeed, by everything which reduces the "vis vitæ" of the animal; poisons, for example, such as sulphuretted hydrogen gas, &c. He has further demonstrated that the intensity of the current is proportionate to the activity of respiration, and to the elevation which the animal holds in the scale of creation whilst its duration after death varies in an inverse ratio.

If a living animal be subjected to the action of a direct continuous current, and a portion of the nervous system be included, contractions are excited, and the animal utters a cry. This occurs when the current is either made or broken. A continuous current passed for a certain time along the course of a motor nerve, so modifies the sensibility, that it becomes insensible to the passage, so long as the current is transmitted in the same direction; but the excitability is restored to the nerve under the influence of the same current transmitted in the contrary direction. Repose produces in the living animal the same effect as the passage of a current through the nerves in a contrary direction. The direct current destroys the nervous excitability much more quickly than the inverse.

If we examine the excitability of the nervous system in a narcotized animal, we shall find that of all stimulants, the electric current is the last which loses the capability of awakening the excitability of a nerve, however feeble that may be.

Matteucci has endeavoured to discover an electric current in the nerves of a living animal, but in vain; and he has come to the conclusion that the electric current of the muscles derives its origin from chemical action.

There exists between the electrical current and the unknown force of the nervous system, an analogy, which if it be not susceptible of the same degree of evidence, is, however, of the same kind as that existing between heat, light, and electricity. In all the phenomena of electric fishes, the faculty of producing electricity, with which they are endowed, is under the direct control of the nervous system; and there is in these animals a structure, a certain disposition of particular parts of their organism, which, by the agency of the unknown force of the nervous system, enables them to disengage electricity.

The electrical current, which traverses a nerve, determines in it a change similar to that produced by the unknown force of the nervous system, when it is there excited by external actions, or by the action of the will.

When the organic disposition of the nerve is perfect, its molecules are deranged in every direction by the application of any kind of stimulant, but always more so in the direction of the electric current than in the opposite direction. An electrical current which traverses a nerve for a certain time, causes a permanent derangement of its molecules, hence the reason why the prolonged action of the same current ceases after a time to produce its peculiar action on a nerve. A current in the contrary direction will bring back the molecules of the nerve into their former condition.

Matteucci sought, as before stated, unsuccessfully, to demonstrate the existence of an electric current in the nerves of a living animal, and he came to the conclusion that there was none. This conclusion was shown to be wholly unfounded by the experiments of Dr. Du-Bois Reymond of Berlin. He demonstrated by experiment the existence of an electric current in every part of the nervous system.* He assumes that the nervous current is produced by the electro-motive molecules in the nerves; and that the electro-motive elements in both the nerves and muscles are to be regarded as in the condition of a closed circuit; and that every current produced by a nerve is to be regarded as derived from a current circulating in the nerve itself.

That the muscles and nerves, including the brain and the spinal cord, are endowed during life with an electromotive power.

That if any portion of a nerve is submitted to the action of a permanent current, such nerve suddenly undergoes, throughout its whole extent, a material alteration in its internal constitution, and on the circuit being broken as suddenly returns to its former condition.

That the exciting current throughout the nerve sets the electro-motive elements in action, and these turn all their positive poles in the same direction as that in which the current proceeds; and their negative poles take the direction from whence it comes.

From what has been stated, it must be evident to every unprejudiced mind, that whether electricity in either of its forms be essentially an integrant of the animal organization or not, it is capable of producing in the living body the most powerful and the most wonderful effects, even from the scarcely sensible excitation of the nervous and motive organs to the total annihilation of organic irritability, and the complete and mortal paralyzation of the vital principle.

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* Untersuchungen ueber die thierische Elektrizität.—Berlin, 1848.

Before proceeding, however, to the general review and ultimate analysis of the known facts and observations, it will be useful, perhaps, to bring a few more of the most interesting under the notice of the reader.

The mode in which electricity acts has been long a subject of controversy, and animal electricity had almost fallen into contempt, when Humboldt came to its rescue, and restored it in some degree to its natural position. In his work ("Versuche über die gereitze Muskel-und Nervenfaser, u. s. w.") he detailed a series of experiments in which he clearly showed, that the opinions respecting the agency of mechanical irritation, and the interposition of blood, mucus, &c. were unfounded, every possibility of error being guarded against, for the circuit consisted of nerve and muscle only.

A prepared frog is affected only when a current is made or broken, or, to speak more generally, only when variations in its strength occur. Thus, during a current of uniform strength, no effect is produced, but when variations occur effects become obviously manifest. Dr. Du Bois-Reymond has announced this as the principal law of electric excitation, and observes as follows:— "The motor nerve is not excited by the absolute amount of the density of the current, but by the variations of this amount from one instant to another, and the excitation caused by these changes is the greater the more rapidly the changes take place, or the more numerous they are in any given time.

The nerves of sensation, as far as they can be submitted to experiment, not only suffer the same irritation as the motor nerves, when variations in the density of the current occur, but they are also affected by a constant current. It is found in most cases when a moderate degree of irritability exists, that according to the direction of the current in the nerve, sometimes the contraction on making, sometimes that on breaking the circuit, is the stronger; and that sometimes even the one or the other contraction is entirely absent. The more violent contraction on making contact takes place when the current passes from the origin to the expansion of the nerves. On breaking contact, the contraction is greatest when the current is in the opposite direction.

The muscular current continually decreases after the death of the animal, or after the separation of the muscle from the body. The diminution of the muscular current after death is proportioned to the diminution of the excitability of the muscle. Both the electro-motive force and the excitability have the same termination, that is, the rigor mortis; caused, as Brücke has proved, by the coagulation of the fibrin contained in the muscles external to the blood-vessels.

The phenomenon of the muscular current must, therefore, be considered as a phenomenon which can only take place in the living tissue. The current when once it has gone, in consequence of the rigor mortis, never returns. Limbs in a state of decomposition after the relaxation of the rigor mortis, no longer possess any perceptible electro-motive force. The nervous current obeys the same law as the muscular current, and hence all the conclusions which were drawn from the phenomena of the muscular current, may be transferred to the nervous current, and it may be assumed that it is produced by electro-motive molecules in the nerves.

When a current acts upon a nerve, the same thing happens in it as occurs in every other moist conductor. Electrolysis is induced, which begins with a polarization of the electro positive and negative elements of the electrolyte. The transit from the natural to the dipolar arrangement excites a disturbance of equilibrium which shows itself, as contraction or as pain, when the circuit is completed. The return from the dipolar to the natural arrangement causes the contraction and pain on breaking the circuit. The stimulation of the nerve by the galvanic current may, indeed, be nothing else than the first stage of electrolysis in the nerve.

In justification of the choice of the name for this permanent alteration in the nerve by the electric current, Du Bois-Reymond recalls to mind the striking analogy, already pointed out, between the law of the galvanic contractions and the law which regulates the induction of currents in a circuit by moving a magnet, or by making or breaking another circuit in its neighbourhood.

Faraday supposed that in a conductor in which a current was induced, a change took place which lasted as long as the inducing current itself continued. He regarded the current on making contact as an evidence of this transit of the wire from its natural condition into an altered one; whilst the return from the altered condition to the natural one announced itself by the shock on breaking the circuit. Faraday called this altered condition of the wire from the making to the breaking of the circuit the electro-tonic state. At first, he could give no actual proof of the real existence of this hypothetical state, but he afterwards, by optical means, proved that a real change in the molecular arrangement of different bodies occurred when they were subjected to magnetic influence.

The following conclusions may be drawn from Dr. Du Bois-Reymond's researches:—

The muscles and nerves, including the brain and the spinal cord, are endowed during life with an electromotive power.

Every minute particle of the nerves and muscles acts, according to the same law, as the whole nerve or muscle.

The electro-motive power lasts after death, or in dissected nerves and muscles after separation from the body of the animal, as long as the excitability of the nervous and muscular fibre; whether these fibres are permitted to die gradually from the cessation of the conditions necessary to the support of life; or whether they are suddenly deprived of their vital properties, by heat, chemical means, &c.

In the different contractile tissues the electro-motive power is always proportioned to the mechanical power of the tissue.

The current in muscles when in the act of contraction, and in nerves when conveying motion or sensation, undergoes a sudden and great negative variation of its intensity.

If any part of a nerve is submitted to the action of a permanent current, the nerve in its whole extent suddenly undergoes a material change in its internal constitution, which disappears (on breaking the circuit) as suddenly as it came on. This change, which is called the electro-tonic state, is evidenced by a new electromotive power, which every point throughout the whole length of the nerve acquires during the passage of the current, so as to produce, in addition to the usual current, a current in the direction of the extrinsic current.

The electro-tonic state of a nerve is the commencement of its electrolysis. The contraction on making the circuit is caused by the nerve passing into the electrotonic state, and that on breaking the circuit by the nerve passing out of this state.

Approaching death and severe injuries of the muscular and nervous tissue cause other modifications of the electro-motive power of the nerves and muscles, of which some are permanent, and connected with the total extinction of that power; others are only transitory.

The electric phenomena of motor and sensitive nerves are identical. Both classes of nerves transmit irritation in both directions.

It has now been fully proved that electricity exists in the living body; and we find it existing in two different states—namely, in a neutral and static condition, that is, in a state of combination, and therefore of rest; and in a dynamic condition, or in a state of current.

The electric current passes from the nervous centres, which are in a state of positive electricity, and the nerves conduct it to the various parts of the body.

The effects of an electric current are found to vary, in a remarkable manner, according to the direction which it pursues. A positive current passing from the nervous centre along the course of the nerve excites muscular contractions. A direct current passing along a nerve of sensation* will excite only contractions, and it appears the nerve will only obey the stimulus of a feeble current. An indirect current causes pain, but no motion. If, in a living frog, the lower limbs be separated from the body, by the division of all the intervening structures with the exception of the sciatic nerves, by which the communication between the several portions is kept up; and if a current be now transmitted through the body of the frog, along the nerves of the legs, violent convulsions will be the result. But if the direction of the current be reversed, no motion whatever will be excited, but the animal will manifest its sense of pain by audible croaking.

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* It seems proper here to observe, for the information of the general reader, who is not necessarily supposed to be acquainted with the principles of physiology, that the brain and spinal marrow are the nervous centres, while the nerves are the mediums of communication. Sensation resides in the brain. Motion and sensation reside in the spinal marrow. The spinal marrow consists of two

A current passing through a nerve of special sense excites it only to the performance of its peculiar functions.

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columns, anterior and posterior, one named motor, and the other sensitive column. The nerves arise from these columns, and immediately after their origin are united by a ganglion, and then proceed to their destination. Thus, by a beautiful provision, the necessary harmony between sensation and motion is preserved. The spinal marrow, consisting of its columns, enters the head at its base, and developing itself forms that great mass termed the brain.

CHAPTER III.

INFLUENCE OF THE ELECTRIC CURRENT UPON THE TISSUES OF THE ANIMAL BODY.

I. *Influence of Electric Currents on the Nerves.*[*]

If a branch of a motor nerve or its root be subjected to a continuous galvanic current, and that even of high intensity, contractions will take place only in those muscles which are supplied by the irritated or excited nerve, and at the *moment* of establishing or breaking contact; but whilst the circuit is closed all the muscles remain motionless. If the nerve be acted on by an intermitting current of less intensity, shock succeeds to shock; and when either the making or the breaking of the contact is effected slowly, *clonic* spasm is produced; but when this is effected with greater rapidity, so that the succeeding contraction begins before the preceding one has ceased, *tonic* spasm is the result.

The contraction in the muscles of a frog's leg, occurring only when contact is made or broken, is explained as follows:—To produce contraction it is only necessary that the variations in the intensity of the current should rapidly succeed to one another. If we transmit a certain quantity of electricity, in a continuous current, through a muscle, the intensity of the current remains the same from the making to the breaking of contact, and during this period no contraction takes place; but the same quantity of electricity, transmitted at intervals, will produce, according to the rapidity of the shocks, either tonic or clonic spasm.*

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[*] Joh. Müller's Handbuch der Physiologie—Ludwig's Lehrbuch der Physiologie—Mémoire sur l'emploi de l'éléctricité en méd, par le Dr. H. Valerius.

The nerves of special sense are affected differently from the motor ones; for, whilst the latter display the phenomena of contraction only on making or breaking contact, and not while the circuit is complete, the former are affected by variations in the intensity of the current, but contractions continue to take place even when the circuit is complete. The effect of electric currents upon nerves of sense, is to bring into play the special actions appertaining to each of these nerves. If, for instance, a piece of zinc is placed on the upper jaw of one side, and a piece of silver in the corresponding position on the other, and a current be transmitted, a sensation, as of a flash of light, will be excited: and this will be still more vivid and distinct if the current be passed through the eyes. If we employ a continuous current, and of some intensity, fire and flame will be seen, and unless special caution be observed, paralysis of the retina* may result. The light seen, whether the current applied be continuous or intermitting, is coloured.

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* Spasm is used to denote inordinate or irregular muscular contraction; and by the qualifying epithets we denote whether this be continuous or interrupted: one form is named tetanus; the other convulsions.

Purkinje and Ruete have observed, that if the positive pole be placed on the closed eyelid, and the negative one be held in the hand, an intense blue light is perceived about the *limbus luteus*, but if the positions of the poles be reversed, a yellowish-red light is seen.

When a current of considerable intensity is transmitted, the whole field of vision becomes equally illuminated. An intermitting current, when passed through the eye in either a transverse or a vertical direction, causes distortion of the pupil, and an incessant flow of tears; but, compared with the continuous current, it produces little or no effect upon the retina.

If the poles be applied one to each ear, on making and breaking contact, a sensation, as if of a loud sound or rushing noise, is felt; or a sort of tinkling which is continued in a less degree, even though the circuit is completed.

When the poles are placed within the nostrils, the negative one, on making and breaking contact, causes a desire to sneeze; the positive one, a peculiar sour smell, which becomes fainter when the circuit is completed.

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* The pulpy expansion of the optic nerve.

If a piece of zinc be placed on the upper surface of the tongue, and a piece of silver on the under, and connection be established as already noticed, a sharp *sour* taste is felt above, and a weak *alkaline* one below. If the piece of zinc be applied to the tip, and the silver be placed on the top, the taste is much stronger than from the other arrangement.*

Du Bois-Reymond thus explains the continued excitement which takes place in nerves of special sense, when exposed to the action of a continuous current of electricity. He observed, that when a continuous current was transmitted through a nerve, the normal current existing in the nerve underwent a change; that is to say—it was increased when the current was transmitted in the same direction with the normal current, but decreased when the current was sent in the contrary direction. The electro-tonic condition commenced instantaneously with the making of contact, and continued so long as the circuit remained closed; but ceased immediately the circuit was broken. The electro-tonic state takes place throughout the nerve and all its branches, and of consequence contractions take place in all the muscles supplied by the nerve or by any of its branches. When an electric current is transmitted along the nerves, and renewed many times in rapid succession, the muscles become *tetanized*, *i. e.*, rigidly contracted; but, on the contrary, when a continuous current is transmitted for a certain time, the muscles become paralyzed. Hence it might be inferred, that the continued passage of an electric current along a tetanic limb, would supersede this condition, and bring on the opposite state—paralysis. Matteucci demonstrated the truth of this conclusion by experiment. The narcotic poisons, as opium, nux vomica, &c., when administered to frogs, stupify these animals in the first place, then the poison over-excites, and lastly, some time before death, the animals are seized with very strong tetanic spasms. If, while they are in this state, a current of electricity of a certain intensity be passed through them, the stiffening of the limbs will be observed to gradually diminish, and the spasms to disappear. After a certain time, indeed, the frogs die, but without exhibiting any signs whatever of tetanus.

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* Pfaff.

2. *Influence of Electric Currents on the Muscles.*

When a continuous electric current is made to act upon a muscle, the influence closely resembles that exerted by the same agency upon a motor nerve, with the single exception that none have yet succeeded in inducing by these means the *electro-tonic* condition.

All the muscles, even in the same individual, are not alike in their contractability, or at least in their aptitude to contract. They vary, in their amount, of both contractability and sensibility. This arises, partly from their anatomical relations, and partly from the difference in the conducting power of the tissues above the excited muscle—such as fat, cellular tissue, &c., and also from the thickness of the epidermis.

3. *Influence of Electric Currents on the Brain and Spinal Cord.*

We are indebted to the researches of Edward Weber* for whatever information we possess upon this subject. If we direct an intermitting electric current along the back, by placing one pole at the top of the neck, and the other at the sacrum, or if we apply the poles, one on either side of the upper part of the spinal column, we shall produce a general tetanic condition in all the muscles of the body and of the extremities, because all their nerves arise from the spinal cord.

If an intermitting electric current be applied to the brain of a frog, the effects vary according to the part of the brain upon which the current acts. If the hemispheres of the cerebrum,† or the cerebellum, be the parts to which the irritant is applied, neither muscular contraction, nor any indication of pain follows. But if we irritate the corpora quadrigemina, we induce contractions in particular muscles, which contractions resemble clonic rather than tonic spasms; and the apparently judicious selection of the muscles, seems like "*reflex action.*"

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* Siehe Wagner's Handwörterbuch der Physiologie mit Rücksicht auf physiologische Pathologie.

† The brain is usually described as consisting of three parts, the *cerebrum*, or brain; the *cerebellum*, or little brain; and the *medulla oblongata*, or prolonged medullary process. The cerebrum is divided into two lateral portions, occupying each side of the cavity of the head from the front to the back; these are named *hemispheres*. The cerebellum, or little brain, is also divided into lateral portions,

4. *Influence of Electric Currents on the Ganglionic System; and the organs supplied with organic muscular fibres.*

We are indebted to the researches of the authority last mentioned (Weber) for the detail of the following experiments, which are unquestionably of great value and importance. He observes that all the organs supplied by the *sympathetic* system of nerves exhibit, under the influence of electric currents, results different from those of animal life.

The movements of the organic system are much slower than those of the animal system, inasmuch as the electric stimulus may have already ceased before the contraction becomes manifest. The degree of slowness, with which the movement follows, differs in different organs, so that there is a gradual approach to the voluntary* system.

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though not quite so prominently or distinctly marked. The nerves which supply the organs of external sense arise chiefly from that part of the cerebral mass which is lodged within the cavity of the skull.

* There are certain parts the actions of which are wholly under

Thus the ureters and gall-bladder are the slowest to contract. Then come the cæcum, stomach, iris, bladder, spermatic cord, gravid uterus, the small and large intestines, œsophagus, and heart. The *stimulated* movements in these muscles, contrary to what takes place in those of the animal system, continue for some time after the action of the stimulus has ceased, and propagate themselves from the fibres in which they first commenced to others more distant.

DIGESTIVE ORGANS.

If the belly of a cat, a dog, or rabbit just killed, be opened, and the intestines placed between two metallic plates in connection with an electro-magnetic machine, an energetic peristaltic motion will be immediately excited. The intestines will rise and fall, and these movements will be propagated till they reach the rectum. The movements caused by the action of the air on exposed intestines are much weaker, and cease much sooner. The momentary influence of the current on the duodenum causes the part touched to contract, and the contraction slowly increases till the calibre of

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the control of the will, as the limbs, &c.—motions of these are termed *voluntary*. Those of the heart, of the respiratory organs, the stomach, and intestines, not being dependent upon, or, indeed, under the control of, the will, are named *involuntary*. Thus, we can move a limb at pleasure; the will cannot interfere in any way with the movement of the heart.

the intestine is quite closed, after which it as slowly relaxes.

But of all the intestines, the cæcum evidences the least sensibility to the electric influence. The muscular fibres of the stomach, whether the longitudinal or those named transverse, contract, and the contractions take place according as the current is applied; and the same holds good as respects the gall-bladder. As regards the spleen, however, the experiment* has given results different from those above mentioned. Cl. Bernard† performed the following experiments, and has lately published the detail with the results. Having exposed the spleen of a dog, he took its dimensions. He then applied the conductors of a powerful electro-magnetic machine in action, placing them in contact with the upper and lower end. In a few minutes the spleen was reduced in length from two to three centimetres.‡ The same experiment having been repeated several times, gave the same results. When the current was transmitted through the organ the decrease took place in its breadth.

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* Wagner, Untersuchungen ueber die Contractilität der Milz mittelst des Electro-Magnetischen Rotations-Apparates, Jen a'sche Annalen, 1849.—Rayer, Expériences sur la contractilité de la rate, Journal des Connaissances médicales, Février 1850.—Harless electrische versuche an einem Hingerichteten, Augsburg allgem. Zeitung, 1850.

† Gaz. Méd. de Paris, 1849.

‡ A centimetre is equal to 39·371 of an English inch, or very nearly so.

ON THE URINO-GENERATIVE ORGANS.

The ureters are sensitive to the electric influence but in a very slight degree; and indeed their contractions are very weak. The bladder contracts quickly and powerfully, and drives out its contents, emptying itself with great force. The gravid uterus of a bitch, under the influence of the electric current contracted forcibly, and these contractions continued for some time after the stimulus had been withdrawn. The unimpregnated uterus gave similar results but in a weaker degree.

ON THE IRIS.

The iris in the mammalia consists of *organic* fibres, whereas in birds these fibres are animal. Thus in the former a gradual dilatation of the pupil takes place on the application of the stimulus, and the dilatation continues after the stimulus has been withdrawn. In the latter rapid contraction of the pupil supervenes, which ceases however on the withdrawal of the stimulus. Dittrich, Gerlach, and Hey * found that when the electro-magnetic conductors were applied to the internal and external canthus of the eye; the pupil assumed an oval form—the long axis of which was in the horizontal or transverse direction; but when applied to the upper and lower border of the orbit, the long axis of the oval assumed a vertical or perpendicular direction.

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* Prager Vierteljahrschrift, 1851. Beobachtungen & physiologische Versuche an den Leichen von zwei Hingerichteten.

ON THE HEART.

When the current from an electro-magnetic machine is directed to the ventricles or the auricles of the heart, a gradual and continuous contraction takes place, and the parts so contracted take no part in those pulsations which circulate the blood. The contraction too continues for some time after the application of the stimulus has ceased. Dittrich and the two last-named authorities, applied one pole of an electro-magnetic machine in action to the right auricle of the heart in a man who had been hanged half an hour before; rhythmical contractions took place in consequence; on stimulating the left side contractions also followed but not near so perfect.

5. *Influence of Electric Currents on the Blood-Vessels and Lymphatics.*

E. H. Weber* made the following experiments with the view of illustrating these points. On a current being directed to the arteries of the mesentery, these vessels contracted to from one-half to one-third their volume; and when the current had been continued for some time, the diameter of the vessels was reduced to one-fifth or even one-sixth the natural size; so that the flow of blood was completely stopped. These effects speedily subside if the stimulus has been but moderate or slight; but if it has been very powerful and energetic, the vessel loses its inherent or natural power of contraction, dilatation ensues, and gradually increases, ultimately amounting to and assuming all the characters of an aneurism.

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* Müller's Archiv, 1847.

Kölliker* applied one pole of the machine to the umbilical artery and vein of a person recently deceased, and contractions followed; the veins expelled the blood and assumed the appearance of strings. The arteries and lymphatics also contracted. The excitability of the different vessels and structures continued after death, respectively, for the following periods,—the irritability remained—

	h.	m.
In the veins for . . .	1	15
In the arteries for . . .	1	10
In the lymphatics for . .	1	12
In the muscles for . . .	1	35
In the nerves for . . .	0	35—45

6. *Influence of Electric Currents on the Skin.*

An intermitting current, besides the increased sensibility before mentioned, causes erection of the papillæ of the skin; erythema; little bladders or bullæ, scurf, &c. according to the sensitiveness of the organ, and the strength and duration of the current applied. Under its influence the derma contracts, the dartoid tissue forms numerous deep folds, with a vermiform motion, and the nipples become erect. A continuous current causes destruction of the cuticular organization. When the electro-magnetic current is directed to the mucous membrane, a smart pricking sensation is felt, and its secretion is increased. A continuous current, when it is very powerful, destroys the mucous surfaces to which it is directed.

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* Kölliker, Lehre von der Contractilität der menschlichen Blut- und Lymphgefässe.

7. *Influence of Electric Currents on the Blood.*

It may be as well here to give the reader some insight into the general constitution and properties of this most important fluid, which, as being so essential to our existence, has been named "*the vital fluid.*" John Hunter and some others have maintained and indeed endeavoured to prove the "vitality" of the blood; but we shall pass over these matters as in no way necessary to our present purpose. Suffice it to say that the blood, while circulating in the vessels is fluid, and presents a bright vermilion colour, or a deep purple, according to the order or system of vessels in which it is circulating. That in the arteries, or, as it is termed, arterial blood, is of the bright vermilion colour; that in the veins, or venous blood, is of a dark purple. The red or arterial blood contains the principles essential to the vitalizing of the organs, and preserving and endowing them with excitability. This fluid, whether drawn from a vein or an artery, and allowed to stand, after a time separates spontaneously into two distinct portions, the one a reddish-coloured solid mass, named crassamentum or clot; the other a wheyish-looking fluid, named serum. The solidification of the crassamentum is technically called spontaneous coagulation. If the serum be heated to about 160° Fahr., a portion of it coagulates and forms a solid, in virtue of the albumen it holds in solution, for this principle solidifies or coagulates at the temperature above named. The crassamentum then coagulates spontaneously because of its fibrin, this being one of the characteristics of this principle; the serum on being heated coagulates in consequence of the albumen held in solution. The clot contains other principles besides fibrin; and the serum, in addition to the albumen, holds several salines in solution.

We may now proceed to consider the effects of electricity upon this important principle—the blood. If recently-drawn arterial or venous blood be subjected to a continuous current, coagulation is promoted in consequence of the separation of the constituents, which takes place under the influence of the electro-chemical decomposition excited. At the negative pole we find the albumen, fibrin, fat, acids, &c.—at the positive the watery and alcoholic extracts, salts, iron, colouring matter, &c.* If the continuous current is applied to the blood while circulating in the vessels, a coagulum forms, which adheres to the sides of the vessels, and impedes and at length wholly prevents the circulation. The coagulum forms in from ten to thirty minutes, and becomes firm enough to close up the calibre of the vessels, and so to arrest further transit. Similar phenomena occur in the blood of the veins when exposed to the influence of a continuous current, but the coagulum is not so consistent, and it is darker in colour.*

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* Heidenreich phys.-chem. Untersuchungen des Blutes durch die electrische Säule in der Neuen Medicinischen Zeitung, 1847.

ON ALBUMEN.

If we pass a current through white of egg, the albumen will be coagulated around the positive pole, but none around the negative. The coagulation at the positive end is owing to the chemical action of the eliminated acids which collect at the positive pole; at the negative, on the contrary, alkali is separated, which, as is well known, not only dissolves albumen but holds it in solution.

If an egg be boiled hard and the solid white exposed to a continuous current, that part in contact with the negative pole will become perfectly transparent, so that writing can be seen through it as distinctly as through glass. This effect of the negative pole I have employed with success in removing opacity of the cornea; and I have no doubt of its efficacy in removing cataract, for I have succeeded in restoring their transparency to the crystalline lenses of pigs and other animals, which I had previously rendered opaque by boiling, or by exposing them to the action of acids.*

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* Asson: Rapporto della comissione che a fatto gli sperimenti sull' électro-puntura come mezzo congelante la sangue nelle arterie e sull' obliterzione delle vase. Annal. Univers, Jan. 1854.

8. *Influence of Electric Currents on the Osseous Tissues or Bones.*

If an intermitting current be directed upon a superficial bone, the skin over which has been previously well moistened, it will cause excruciating pain, with a feeling as if being bored through. This arises from the irritation produced in the highly-sensitive nerves of the periosteum, or membrane investing the bone. The flat† bones are by far the most sensitive to the agencies of electric currents.

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* See Lawrance on Electricity and Galvanism.

† The bones have been divided into round or cylindrical, and flat or plane bones. The thigh and arm afford examples of the former. Those of the skull and the shoulder-blades instances of the latter.

CHAPTER IV.

ELECTROLYSIS, OR ELECTRO-CHEMICAL DECOMPOSITION.

ELECTROLYSIS is a compound word derived from the Greek. It is formed from the Greek name for amber, ἤλεκτρον, which, as already explained, has been applied to denote electricity, and another Greek word λυσις, dissolution or the separation of compound bodies into their perfectly simple constituents. Electrolysis, therefore, signifies, electro-chemical decomposition, or the reduction of compounds into their constituent elements. One essential condition of electrolysis is liquidity: and the current of a powerful battery will be completely stopped by a film of ice, not more than one-sixteenth of an inch in thickness.

The decomposition of water * affords one of the

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* In the opinion of Faraday, the conduction of electricity through liquids is accompanied by, if it be not owing to, the successive decomposition of the intervening particles. When a copper and zinc

simplest, and, at the same time, the most satisfactory examples of the decomposing power, and effect of galvanic electricity. If the connecting-wires from the opposite poles of a galvanic battery be immersed in a glass containing acidulated water, immediately a copious evolution and extrication of gas will be perceived to take place from each of the poles. If we examine the quantities disengaged, we shall find that the quantity evolved from the negative pole will exceed, by *double*, that from the positive; or, in other words, the quantities will bear to each other the relation of two to one.

We shall find, on the examination of their qualities, that the gas evolved at the negative pole is pure hydrogen; while that which makes its appearance at the positive is oxygen. It is to be clearly understood,

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plate, for example, are connected together and immersed in diluted acid, the oxygen in the particle of liquid contiguous to the plate enters into combination with the metal, and its equivalent quantity of hydrogen is disengaged. The hydrogen is not immediately liberated, but is transferred from particle to particle of the liquid in a continuous chain, till it reaches the conducting plate, where, not meeting with any more liquid particles to which it can be transferred, it is liberated in the gaseous form. The intervening particles are supposed to undergo temporary decomposition during this transfer from plate to plate, and to assume a polar condition, the oxygen and hydrogen occupying opposing places in each particle of liquid.

According to this view of the conducting power of fluids, no fluid can conduct electricity, unless it be capable of being decomposed, the conduction being necessarily accompanied by a train of successively decomposed particles.

that the quantitative proportions here indicated are by *volume* not *weight*, which are the exact proportions, by measure, in which hydrogen and oxygen are combined in the formation of water.

This is a case of simple decomposition, in which the elements of a simple binary compound are separated, and appear each at its respective pole; but far more complicated, and far more extraordinary phenomena, may be effected by galvanic agency. Thus the following experiment illustrates, in a much more remarkable manner than does the decomposition of water, the transfer of the elements of compound bodies. These elements may be not only separated, but made to pass through principles, between which and themselves there exists mutually a strong tendency to unite, and yet this tendency will be completely suspended.

Put into three distinct glasses—into one a solution of common salt, into a second a solution of ammonia, and into the third a solution of litmus. Let the glasses be connected by means of asbestos, and then immerse the poles of a galvanic battery in the first and third glasses of the series, the intermediate one having no *direct* connection with the battery by its poles. It is evident that the fluids in the glasses Nos. 1 and 3 are alone exposed to the direct influence of the galvanic power. On the current being established as above, we shall find that the fluid in No. 3, the colour of which was naturally blue, soon changes to a *red*. This is owing to the transfer of an acid from some part of the arrangement to No. 3; and as the solution of salt in No. 1 is the only one of the solutions which should furnish a principle capable of acidification, the acid must be derived from this source. But if we examine the phenomena more closely, we shall find that not only have decompositions been effected, but new combinations also. For instance, the common salt, as before noticed, consists of chlorine and sodium. Chlorine, in its free state, destroys or discharges vegetable colours, as is well known to bleachers; hence, if on the decomposition of the salt, one of its elements, the chlorine only, were transferred to No. 3, its blue would be destroyed. But as it is changed to *red*, evidently an *acid* must have been generated, and this could be effected only by the union of an *acidifiable* with an acidifying principle. Hence then, by some means or other, the chlorine must have combined with some principle, by which union an acid was formed. The truth is, that not only was the salt decomposed, but the water also, and the elements of each separated.

The elements of water, it has been already stated, are oxygen and hydrogen. Now hydrogen readily unites with chlorine, and forms a compound hydrochloric acid. The chlorine, at the moment of its separation, meeting with the hydrogen of the decomposed water, unites with it, and forms the *hydrochloric acid* which reddens the litmus, and may readily be chemically discovered in the fluid of No. 3. The other principle of the salt, the *sodium*, combines with the *oxygen*, the other element o the decomposed water, and forms *soda*, which may be detected in solution in No. 1. Thus it is evident that not merely one, but two principles are reduced, and their elements transferred and united so as to form altogether new compounds.

Nor are the above the only or the most surprising of the extraordinary phenomena. It will be recollected that the intermediate or central glass, No. 2, contained a solution of ammonia. Now ammonia and hydrochloric acid have a very powerful attraction for each other, and a great tendency to unite, yet it would seem as if the hydrochloric acid, passed through the solution of ammonia, wholly regardless of the natural tendencies, nor stops its progress till it has reached the solution of litmus, where it exhibits its chemical powers upon the colouring matter of the litmus. This peculiarity of influence of the electric current, fully confirms the hypothesis of Faraday, respecting the mode of electric conduction through fluids.*

The powerful agency of galvanic electricity in controlling, modifying, and subverting chemical affinities, led Sir H. Davy, as before observed, to infer that chemical affinity itself is but a modification of electric attraction, and that those bodies, which combine most energetically, possess internally, and in the greatest degree, positive and negative electricity. Viewing, therefore, chemical affinity and electricity as identical, he conceived that the galvanic battery would afford the means of separating the most intimately-combined elements, by overpowering or suspending the attractive forces by which they were held together.

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* By that hypothesis the apparent suspension of chemical affinity in the intermediate vessel is attributed to the continued transfer of the acid from particle to particle of the fluid with which it ultimately combines, no free acid being actually liberated till the chain of connexion is terminated by arriving at the opposite pole of the battery.

Faraday has clearly established the interesting and important fact, that electro-chemical force is definite in its action, and that the chemical power of a current *is* in direct proportion to the absolute quantity of electricity that passes. Faraday thus expresses his theory :—"The chemical decomposing action of a current is *constant for a constant quantity of electricity*, notwithstanding the greatest variations in its sources, in its intensity, in the size of the electrodes* used, in the nature of the conductors (or non-conductors) through which it is passed, or in other circumstances."*

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* What are named the poles of a voltaic battery are merely the surfaces or doors, as it were, through which the electricity enters into, or passes out of the body undergoing decomposition. Faraday has named them "*electrodes*," a term derived from the Greek name of amber, as before explained, and *ὁδὸς*, via, a way or course; thus expressing the substance or surface, which, whether air, water, metal, or whatever else, may serve to convey an electric current into or from the body undergoing decomposition, and which bounds its extent in that direction. The surfaces of, or through which, the electric current enters and leaves a body undergoing decomposition he names the "*anode*" and the "*cathode*." These words are de-

The demonstration of this theory, by numerous experiments, has tended strongly to confirm the opinion, that electric and chemical affinity are but different modifications of the same force, for it is found that the amount of decomposing effects, in all substances, agrees very closely with their chemical equivalents.

The discovery of the law of the definite action of electro-chemical forces, and that the chemical power of an electric current is in direct proportion to the quantity of electricity which passes, has opened the way to the determination of the absolute quantities of electricity belonging to different bodies in their natural states. Faraday observes, "considering this close and twofold relation, namely, that without decomposition, transmission of electricity does not occur, and that for a given definite quantity of electricity passed, an equally definite and constant quantity of water or other matter is decomposed; considering also that the agent, which

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rived from the Greek words *ὁδὸς*, a way, and the prefixes *ἄνα*, upwards, and *κατὰ*, downwards, in conformity with the ideas of the sun's rising and setting. The analogy is taken from the magnetism of the earth, which is supposed to be owing to electric currents passing round it in an invariable direction from *east* to *west*. The *anode* is, therefore, that surface at which the electric current enters, and is, therefore, the *negative* extremity of the body undergoing decomposition. The *cathode* is the surface at which the current leaves the body undergoing decomposition, and is, therefore, its *positive* extremity.

* Experimental Researches.

is electricity, is simply employed in overcoming electrical powers employed in the body subjected to its action; it seems a probable and almost a natural consequence, that the quantity which passes is the *equivalent* of, and therefore equal to, that of the particles separated, *i. e.*, that if the electrical power, which holds the elements of a grain of water in combination, or which makes a grain of oxygen and hydrogen in the right proportions, unite into water when they are made to combine, could be thrown into the form of a current, it would exactly equal the current required for the separation of that grain of water into its elements again."

Such are some of the extraordinary powers of electricity as a chemical or decomposing agent. Nor are these all; even simple bodies, when subjected to its action, acknowledge its power. The metals, gold, silver, copper, lead, &c., and even the most refractory of all, platinum itself, when in thin leaves and subjected to the action of a galvanic battery, not only fuse, but are volatilized, the flame of each metal, during its combustion, exhibiting a characteristic light. One, however, of the most interesting, and perhaps the grandest of the phenomena exhibited by electricity, is the effect upon charcoal in a vacuum. If charcoal be exposed to the galvanic agency, with access of atmospheric air, it burns rapidly, combines with oxygen, and gives rise to the formation of carbonic acid gas. But if submitted to the same agency while enclosed in a vacuum, the access of air being completely barred, a brilliant phenomenon is displayed. The charcoal ignites and glows, but undergoes no alteration or change. During the period of this ignition it emits a light, the intensity and brilliancy of which are exceeded only by that of the sun itself.

In conclusion, it may be proper to refer to the chemical changes which are constantly going forward in the body from the friction of dissimilar substances, and variations in the temperature of different parts of the body, and the agencies of light.

Every chemical process, through which these changes take place, has the effect of *polarizing* the electricity; therefore, there can be no doubt that this agent plays a very important part in the living organism,* and that the quantity of polarized electricity in the body is very considerable.

It can hardly be denied that the phenomena of animal life are chiefly the results of a grand series of chemical agencies; that by each inspiration, chemical changes are brought about highly essential to vital existence: for instance, the union of the carbon of the blood with the oxygen of the atmosphere and the emission from the system of the resulting and *poisonous* carbonic acid gas. The simple elementary bodies, sulphur, phosphorus, and hydrogen, constituting important components of the food, by which we are sustained, become, by their oxidation or union with oxygen, sources of free electricity.

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* Chaptal relates the following curious anecdote of the Emperor Napoleon, who, on seeing the voltaic battery of the French Academy in action, remarked, "Voilà, l'image de la vie: la colonne vertébral est le pile, la vessie le pole positif, et le foie le pole negatif."

The effect of electricity upon the different tissues of the living body will, of course, vary with the intensity and the quantity. If the intensity of the current is great, it will cause convulsions and contractions more or less violent. And these movements will be attended with painful feelings if the direction of the current be altered, which is always the case when an induced current has been excited. If a series of powerful currents be passed in rapid succession through a limb, a state of complete tetanic convulsions will be excited; and this will be accompanied with feelings of intense pain, especially if the currents be alternately reversed.

It follows, from these observations, which my own experience has fully confirmed, that the majority of the electro-magnetic coils, as at present constructed, are by no means adapted for the application of electricity as a remedial agent. On the contrary, they are not unfrequently a *cause* of great positive *injury*.

It cannot, in my opinion, be too clearly or too strongly impressed on the mind, that an electric current, to prove beneficial in its medical effects, must be of low intensity; large in quantity, and must flow in *one* direction.

That electricity can exert a powerful physiological influence, admits of no dispute. Indigestion—an inability to reduce, convert, and assimilate the food—is often dependent upon an incapability in the stomach and other digestive organs to secrete their fluids in a state capable of acting in a proper manner upon the materials destined to afford nutrition to the animal. The result is often the conversion of the food into principles or compounds, wholly unfitted for support, and hence the generation of gases and fluids which cause mechanical distention and all its attendant evils; or pathologically such as produce noxious compounds which excite irritation, followed by inflammation, to end, ultimately, in disorganization or change of structure. Let us present to the reader a familiar, and, consequently, more easily understood instance. Common salt forms, not only an important article of food, but also an essential and active agent for its reduction. Salt is what is termed a "simple binary compound," that is, consisting of two simple elements*—chlorine and sodium. A part of this salt dissolved in the fluids of the stomach, enters the blood as salt, and may be easily detected in it. Another portion undergoes decomposition, and is resolved into its elements; one of these, the chlorine, unites with hydrogen, and forms *hydrochloric acid*,* which assists in the solution and reduction of the food; the other element, the sodium, unites with oxygen forming *soda*, a very important constituent of the bile secreted by the liver.

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* In chemical phraseology an element is not necessarily a simple substance; for example, the constituents of common salt, *chlorine* and *sodium*, are purely simple; on the other hand, let us take Epsom salts, the elements of which are sulphuric acid and magnesia, both compounds consisting of, the first *sulphur* and oxygen, the latter *magnesium* and oxygen. These two, though compound bodies, form the elements of Epsom salts, and as such have received the name of the *proximate* elements; but the *sulphur*, the *magnesium*, and the *oxygen*, which combined as the acid and base, form the proximate or compound elements, being individually the simple elements of the compound are called the *remote*, or ultimate elements. Thus it will be understood how common salt—chloride of sodium—consisting of two simple *elements*, is a *simple binary* compound; but Epsom salts or sulphate of magnesia, consisting of sulphuric acid and magnesia, both simple binary compounds, is a *double binary* compound.

It may here, perhaps, be asked, what can be the influence of the minute evolutions of electricity arising from the decomposition of a few grains of salt and water, and the resolving of them into their elements. Professor Faraday states that during the decomposition of nine grains of water, an amount of electricity is set free, greater by far than the amount which is called into such terrific action in the production of those vivid flashes of lightning which so often attend storms. Becquérel has shown that the electricity evolved during the decomposition of a few grains of common salt, is capable, if properly managed and directed, of producing chemical changes, precisely analogous to those, which, in the hands of Sir H. Davy, required, for their demonstration, the enormous batteries of the Royal Institution, consisting of six hundred double plates four inches square.

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* Hydrochloric acid in its free state, and indeed chlorine, nitric, and acetic acids, have been found in the stomach by Prout; and the fact of their existence in this viscus has been confirmed by Venables and others. These acids, especially the hydrochloric and acetic, dissolve the food, and assist in reducing it to that state or condition necessary to fit it for the digestive action of the peculiar secretions of the stomach, a process known to physiologists, and named *chymification*.

A very energetic current may be readily detected when a piece of platinum is placed in the acid contents of the stomach of an animal, and another in the alkaline secretion of the liver. The powers of electricity as a digestive agent, and, indeed, in some degree replacing the "vis nervosa" of the pneumo-gastric nerves, has been clearly demonstrated by Dr. Wilson Philip, in his work "On Indigestion." Having allowed two rabbits, each to take a hearty meal, he divided the pneumo-gastric nerves in both. The one was left undisturbed; but in the other, the divided ends of the nerves were connected with a galvanic battery. In the first rabbit, the food remained in the stomach unacted upon, and wholly unaltered. In the second, the digestion of the food went on, and was completed through the agency of the galvanic connection. Dr. Philip also tells us in his work that he has very often promoted the process of digestion in persons in whom this function was weak or impaired, by passing a current of electricity in the direction of the nerves, so as to compensate, in some degree, their enfeebled action. The process, however, adopted by Dr. Philip, though satisfactory, to a certain extent, in its results, is not in accordance with the enlightened principles of the present day, and I must, therefore, refer the more inquisitive reader for the details to Dr. Philip's own work.

CHAPTER V.

ON THE INTRODUCTION OF MEDICINAL SUBSTANCES INTO THE HUMAN BODY BY GALVANIC ELECTRICITY.

We have shown, upon several occasions in these pages, the immense power which electricity exerts upon those affinities which preserve the union of the elements of compound bodies, and that, however strong, or whatever the power that tends to continue the union, it still yields to the influence of electricity, and is at once dissolved. Nor is this all; they are not only decomposed, but the elements are forced asunder, transported to great distances, and even passed, without combining, through substances for which they have very strong attractions, and with which, under ordinary circumstances, they would have united.

It is well known to physiologists that there are a number of salts (that is, compounds consisting of acids and alkalies, or other salifiable bases) forming a part of the human body. The salines consist principally of the phosphoric, sulphuric, and muriatic acids, united to the alkaline and earthy bases. That these may be separated, even while within the body, by means of a continuous current, has been fully proved by Davy, Becquérel, and Fabré-Palaprat. Sir H. Davy having placed his fingers, previously well wetted in distilled water, in the positive part of a voltaic circuit, phosphoric, sulphuric, and muriatic acids rapidly passed into the water from his body. Upon making a similar experiment at the negative side, fixed alkali made its appearance. "Now," says Becquérel, "since acid and alkaline substances can thus be separated from their combination in the living body by means of electric power, there is reason to believe that by the same means may be introtroduced into the living body different substances capable of reacting on the organs in different pathological cases."

Dr. Fabré-Palaprat* has made some experiments which seem to hold out the prospect of the most interesting results, especially if the subject obtain the attention and zeal of the profession. Palaprat operated as follows:—Having made both the arms of a woman as dry as possible, he applied to one a compress soaked in a solution of iodide of potassium, and covered this with a plate of platinum, in communication with the positive pole of a pile formed of thirty elements, and charged with a liquid adequate to produce decomposition. On the other arm he placed a compress moistened with amidine, which, being covered with a plate of platinum, was made to communicate with the negative pole. In a few moments the amidine assumed a blue colour, clearly proving that the iodine had been transported through the interior of the body, since the skin, which was sufficiently dry, could not give passage to a current.

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* Becquérel, Traité expérimental de l'Electricité, tom. iv.

In Davy's celebrated paper on "Some Chemical Agencies of Electricity," read before the Royal Society,* will be found an account of the passage of acids, alkalies, and other substances, through various attracting chemical menstrua.

Hence, then, it would appear that the constitution of the fluids of the body may be altered, certain principles may be withdrawn, and the ratio of the remaining principles may be changed. "Thus," observes Mr. Donovan, "in the same manner a new mode of entrance into the human body of active remedial agents is indicated more quick, more direct, more certain, than any other known, without the risk of being injured or altered by digestion, or of being eliminated by excretion."

We may profit by these experiments, and thus, by acupuncturation, apply our remedies directly to those parts upon which we wish more immediately to act; especially when we find that the internal application proves inefficacious.

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* 20th November, 1806.

It is scarcely necessary, specially, to allude to the important agency of electricity in the depositing metallic coatings, as in electro-plating, gilding, &c. This application is now familiar to almost every one, and its great importance to the manufacturer will hardly be denied. Again, lightning affords the most positive proofs of the wonderful powers and agencies of which electricity is capable. For instance, lightning will melt the solder which holds metals in contact, and transport it to a considerable distance. We all know that even the immense bells in our churches have been melted by the lightning, and whole buildings have been laid in ruins.

Galvanism has also been applied, and with the most complete success, to the purposes of toxicology. Rossi and Gavarret have published the results of some experiments, but have omitted to inform us upon the mode of their proceedings.* Dr. Edmund Davy, by means of a galvanic circuit, reproduced poisons having a metal for their base. Arsenic, mercury, lead, copper, and antimony, the most common and the most virulent of the poisons, have been deposited, through the agencies of electricity, from solutions in which they existed, in the most minute quantities conceivable; of these, arsenic is the most difficult to deposit, owing to the readiness with which it combines with hydrogen to form arseniuretted hydrogen. Mercury may be deposited by the most simple means. If a drop of a solution of corrosive sublimate be put upon a sovereign or a plate of gold, and a piece of iron be pushed through the solution, so as to touch the gold, an immediate deposit of *metallic* mercury takes place, and an amalgam is formed at the place of contact.

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* Compt. rend. de l'Acad. tom. xi. Concours de physique médicale, p. 149.

Heidenreich precipitated various substances from the urine which had been previously mixed with this fluid, for the purposes of experiment. To show how delicate the test, he took an ounce and a half of a solution of iodide of potassium—the solution so weak that, when tested with sulphuric acid and starch, it afforded no evidence of the presence of iodine, but, when submitted to the galvanic test, *ten drops* gave marked indications of the presence of the iodine.

Gautier de Claubry* employs the following method for the detection of mineral poisons when intermixed or combined with organic matters. He first destroys the organic matter with nitric and muriatic acids, and then subjects it to the action of the battery, when the poison will be found deposited upon the platinum plate in from ten to twelve hours.

That certain substances are carried by the galvanic current, and conveyed through intervening or interposed matters, may be readily proved by experiment. If, for instance, we place in the palm of the hand some cinnabar or vermilion, and on the back of it a plate of iron, and then make contact with a galvanic battery, a sulphuret of iron will be formed on the iron plate. Evidently the sulphur must have been conveyed by the electric power through the hand. Again, place an amalgam of mercury in the palm of the hand, and some sulphur on the back of it, on establishing the contact cinnabar, a combination of mercury and sulphur, will be formed. If a raw potato be connected with the positive pole of a battery, and a saucer filled with the tincture of iodine with the negative, and connexion established by connecting the potato and the iodine with a platinum wire, in about ten or twelve hours a dark-blue substance will be seen collecting around the positive pole, arising from the action of the iodine upon the starch of the potato: thus proving that the iodine must have been carried along the platinum wire.

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* Jour. Pharmaceutique, 1850.

Now, as these facts clearly prove the transmission of chemical agents through various mediums, and their final deposition, it would naturally follow as an inference that such powers would enable us to introduce medicinal substances, and deposit them in the organs and tissues of the human body—an inference which has been fully confirmed. If an egg (boiled hard) be placed on a piece of copper, in connexion with the positive pole of the battery, while the egg is connected with the negative pole, the egg will be pervaded by the copper, which will be evidenced by the egg becoming of a dark-green colour. Here are evidently the transfer and deposition of inorganic matter into the substance of organised.

But Fabré-Palaprat has actually successfully treated, by the galvanic introduction of iodine, several cases of bronchocele which had previously resisted all the other recognised modes of treatment. Becquérel ran into his own arm a needle, and connected the latter with the positive pole of a battery; he then placed his hand in a solution of iodide of potassium connected with the negative pole, when he found that the iodine collected around the needle.*

Breschet mentions in his Clinique that scrofulous enlargement of the glands of the neck were cured by the galvanic introduction of iodine. Klencke testifies to the success of this mode of treatment in bronchocele or goître; gouty and rheumatic deposits about the joints; enlarged glands, &c. He also asserts that he has produced emesis, or vomiting, by the galvanic introduction of tartar emetic into the body; and we have abundant proof that the vegetable alkaloids—morphia, strychnia, atropia, veratria, &c.—may be introduced by this method into the system.

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* Becquérel, 1836, tom. iv., p. 321.

PART II.

ON GOUT AND RHEUMATISM.

CHAPTER VI.

We have now considered at some length the action of electricity upon matter, whether organised or unorganised. We have seen that, upon whichever form it may act, it is capable of producing the most wonderful and indeed the most incomprehensible effects. In the organised forms life itself has been suddenly arrested, and by a modification of the agent the functions of the different organs of the living system have been suppressed, or when languid, excited and recalled to increased activity. In the unorganised forms we have seen the most refractory bodies or compounds brought under complete subjection, and rendered amenable to the control of the electric agency.

It has been shown, in the preceding pages, that notwithstanding the violent effects which electricity can produce, whether upon the organs of the body or upon their functions, still, under proper limits and restrictions, it appears to be the means through which the phenomena of life are excited and made manifest. It has been proved that currents of electricity pervade the frame, and it is by no means improbable that it is one of the principal, if not the sole, agent by which life is maintained.

If, then, electricity be so essential to animal existence, if a due control and confinement within certain bounds be so absolutely necessary to the well-being of the animal, we can readily conceive that any derangement in the action or in the operations of an agent playing so prominent a part must naturally be productive of corresponding morbid manifestations in the phenomena of health. If we concede so much, it must follow as a consequence that the due regulation of the electric principle of life presents the most obvious means of controlling or arresting disease.

Is electricity, then, to be exempted from the category of laws which determine the relations of the animal frame to the various agents by which its structure and functions may be affected? Is the human body so insensible to electrical agencies and their influences that it is matter of little moment whether it be overdosed with this subtile agent or disturbed by the transmission of unnatural and conflicting currents? These are questions which analogy would readily answer; but experience has already determined them. In the preceding pages we have shown from experiment and acknowledged facts that the transmission of electrical currents as a therapeutic, requires as much care and consideration as the application of any other powerful remedy, or indeed any other means capable of affecting the conditions of the animal machine. Electricity, as a curative agent, must be applied with the greatest care ; in most, if not in all diseases, its application should never be attempted by those unacquainted with the anatomy and delicate structure of the organs and tissues affected, and the effects produced upon them by electric currents.

Here we may once more remind the reader that the effects of the electric current vary not. only with its intensity, but also with its quantity. If, for instance, the current be of great intensity, spasmodic contractions and convulsions will be the result, and these will be more or less violent, according to the quantity and the degree of intensity.

It is a well-established fact that if an electric current be passed along a nerve for a certain time, it will destroy its sensibility; and that the limb, supplied by a nerve which has been subjected to a *direct* current, becomes incapable of voluntary motion—that is, paralyzed ; but after an interval of repose the nerve again becomes excitable by the *same* current, or without such interval by the transmission of the same current in the contrary direction. We know that an intermitting current applied to a nerve in a living animal causes tetanic contractions or convulsions in that animal, and after a certain time the excitability of the nerve is entirely lost. These are facts of essential moment to guide us in the treatment of paralysis. The sensation caused by the passage of the current should not be stronger than that of a slight *pricking*, somewhat similar to that felt in a limb in the state commonly called "asleep;" if it exceed this the application will be injurious.

It is essential that in regulating the intensity of the current we should consult the feelings of the patient. It is generally the most prudent plan to begin with currents of the weakest power, and gradually to increase their strength so long as the application causes no pain. It may also be laid down as a general rule that the current when applied to any one part, should not be continued longer than from fifteen to twenty minutes; when it is deemed desirable to make the application more general, the duration may be extended to thirty minutes. Persons are occasionally met with whose nervous susceptibility is so great that they cannot endure it for more than two or three minutes.

One application in the day will, in most instances, be found sufficient; in some, however, benefit may be derived from a more frequent use of the remedy; and cases are sometimes met with in which it can be applied with advantage only on the alternate days.

Although a single application is often attended with marked benefit, yet this must not be looked for as the invariable result. Chronic affections, especially when of long standing, require perseverance and the continued use of this agent; and few cases occur in which some benefit will not be derived from its judicious application, even though a complete cure may not be obtained.

In order to prevent any misapprehension, I think it right here to observe that I do not advocate the employment of electricity as superseding other modes of treating disease. In truth, I look upon it merely as an auxiliary; and my own experience justifies me in bearing testimony to its value in giving efficacy to remedies which, without the assistance of electricity, had entirely failed.

Galvanism has been used with the view of effecting electro-chemical decomposition, or electrolysis of unnatural growths, and morbid generations in different parts of the human body—such as the absorption of morbid deposits; the disintegration and solution of calculi, &c., for the purpose of facilitating their removal. But upon these matters no definite directions can be given; the adaptation of it to these purposes must be left to the judgment and discrimination of the medical practitioner.

Having so far reviewed those general principles which should influence us in the application and adaptation of electricity as a therapeutical agent, it now remains for me to enter upon the more immediate object of these pages. In the foregoing remarks I hope I have succeeded in satisfying the reader that electricity is an immense power; that not only every kind of inorganic matter yields to its influence, but that organised bodies are also under its control. Nor have I vainly endeavoured, I trust, to shew that like the powerful agents with which our Materia

Medica furnishes us for the cure of diseases, electricity may be productive of good or evil, according as it is managed with judgment and skill or otherwise.

Rheumatism is a disease of a special nature, and in fact often followed by special consequences of more or less severity, which prove not unfrequently a source of the greatest misery to the unhappy sufferer. How often do we see the shrivelled limb; the stiffened joint; and a frame, once vigorous and capable of the most powerful exertion, reduced to a state of helplessness bordering almost upon decrepitude. Surely any means calculated to arrest the progress to such a condition, or to rescue the individual from his impending danger, must be a matter of the deepest interest; and to restore him from a state of misery and suffering to one comparatively of good health will no doubt insure that attention which the importance of the subject so justly claims.

It would be quite foreign to the purpose, and wholly inconsistent with the objects of this essay, to enter upon a full and detailed history of rheumatism; nor is it necessary to lay before the reader more than a general outline of the disease, its symptoms, and the structures in which it most commonly takes up its abode.

CHAPTER VII.

ACUTE RHEUMATISM.

RHEUMATISM is a very common disease, always very painful, and sometimes even dangerous. It prevails under two forms, namely, the *acute*, commonly known as "rheumatic fever;" and the chronic, which is often the sequel to the former. The latter may, however, occur as the primary affection, without any antecedent attack of the acute.

By the term rheumatism we understand inflammation of a specific kind. In what is named rheumatic fever, the excitement often, indeed generally, runs very high, and the symptoms not unfrequently become alarming. The local affection presents, in an exquisite degree, the four phenomena enumerated by Celsus as the characteristics of inflammation—namely, redness and swelling with heat and pain.

Inflammation may terminate in several ways—it may

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[*] "Notæ vero inflammationis sunt quatuor rubor et tumor cum calore et dolore."—Aur. Corn. Celsi de Medicina, lib. iii. cap. x.

end in resolution, which is the gradual cessation of the symptoms without any obvious or inconvenient result; in suppuration, which is the formation of matter; in effusion, the pouring out of serous fluid into the cavities; or a fibrinous deposit may take place in the inflamed parts.

The first mode of termination—resolution—is not uncommon in rheumatism; but the second—suppuration—occurs very rarely. Effusion takes place most frequently, and lymph and other morbid deposits occur, proving a complete barrier to the due performance of the regular functions of the parts.

Rheumatism is essentially an inflammation of the fibrous tissues, and mostly seizes upon the fibrous structures lying around the large joints, for instance, the tendons, ligaments, &c. It is not however confined to these parts alone; for sometimes, though fortunately more rarely, it attacks the membranes of the heart. When a translation of this sort occurs, it is attended with the most violent and irregular palpitation; severe pains and other most distressing symptoms; and not unfrequently proves rapidly—even suddenly—fatal.

Rheumatic inflammation presents another peculiarity in relation to the parts which it attacks. The disease is found to prevail mostly in the larger joints, as the wrist, elbow, shoulder, knee, or ankle, the gouty inflammation attacking the smaller joints, as those of the toes and fingers.

Acute rheumatism generally arises from exposure to wet and cold, and comes on suddenly and indeed without the slightest warning. It is principally a disease of youth, prevailing from the age of puberty to that of forty, and attacks the male sex much more frequently than the female. It has a great tendency to fly from one joint to another; thus after having suddenly appeared in one joint, it will as suddenly leave that joint to appear with all its original violence in some other, and so proceed till it has perhaps gone the round of all the larger joints in the body.

Of the acute rheumatism there are two varieties. In one the inflammation commences in the immediate *neighbourhood* of one of the larger joints—not *in* the joint itself, but *near* to it, attacking the tendons, fasciæ and ligaments. At first the redness and swelling are but trivial; but after the pain has continued for some time, there may be observed a puffiness around the parts affected, owing seemingly to turgescence of the blood-vessels, with at length a slight degree of pitting; or *œdema* even may supervene from effusion into the surrounding areolar tissue; and whatever redness may be present is disposed in streaks following the course of the tendons.

The other variety attacks the synovial membrane, and more frequently that of the knee in preference to any other part. The pain which ushers in the complaint is soon attended with some degree of perceptible swelling, and slight redness of the skin. This swelling is not so much the consequence of turgescence, or even œdema, as of fluid poured out into the cavity of the joint, and indeed the form and character of the swelling clearly show that it results from the fulness and distention of the synovial membrane. It is tense and elastic, and fluctuation is often distinctly perceptible in the superficial joints. In the first variety the inflammatory fever runs high; the perspirations are profuse and acid, and the urine high-coloured, depositing a copious lateritious sediment. The tendency to metastasis to the heart is greater in this variety.

In the second variety the fever is not nearly so intense, or it abates as the joints begin to swell.

Acute rheumatism is really a blood disease; the circulating blood carries with it a poisonous material. The attack begins with pain in the limbs and most of the larger joints, with tenderness and a slight degree of tumefaction and redness. The joints and muscles become affected in succession as above mentioned. The pain is comparatively slight while the patient is at rest; but becomes excruciating on any attempt to move the muscles. There is an expression of great anxiety, profuse perspiration, and the tongue is loaded but moist. The patient generally lies on the back, quite motionless, as any attempt to move is immediately checked by the intensity of the pain. The perspiration, which is acid, causes an exhalation of a peculiar odour. The pulse is frequent, strong, and full; the bowels for the most part obstinately costive; the urine deposits the lithates in abundance, especially on the decline of the disease. The sensorium is seldom disturbed, unless the heart becomes affected.

It has just been stated that rheumatism is, strictly speaking, a diseased or morbid condition of the blood. Some of the organs either generate or separate noxious principles, which are poured into the blood. Thus, when the tissues become effete or useless, they undergo decomposition, and their elements recombine and form principles which, entering the blood, would, if carried throughout the circulation, prove destructive to animal life, but this has been obviated by a most wise and wonderful foresight. There are a certain set of organs named emunctories, by which the blood is freed from these contaminating principles, and so purified is rendered fit for the general circulation. The principal of these emunctories are, the lungs, the kidneys, and the skin. These organs are constantly separating from the blood those deleterious principles with which it becomes contaminated through the ordinary processes of nature, and it is this peculiarity of function which gives to the excreted matters respectively their special characters. For instance, we find the air expired from the lungs loaded with *carbonic acid gas;* the urine contains a number of salines in solution, together with certain artificial principles, urea, uric acid, &c., the results of the decomposition of the effete tissues, the reorganization of their elements, and the formation of new compounds. The skin also is a depurating organ, and assists in freeing the blood from noxious matters received during its circulation. The skin is at all times throwing off, through what has been named the "insensible transpiration," these noxious products. Hence we find that these natural actions cannot be suppressed or arrested without causing disease more or less severe in proportion to the degree of interruption or impediment which has been sustained. If, for instance, a person be exposed to cold and damp, the insensible perspiration is thereby impeded or suppressed, and every one is familiar with the constitutional results—fever, catarrh, influenza, &c.

We have now shown that these noxious principles of *natural* generation are thrown off and evacuated through the agencies of certain organs termed "emunctories." There is, however, a tendency in certain organs, under peculiar conditions, to generate acids altogether foreign to their normal actions. Now, these tendencies are owing to great and irregular changes in the chemical functions of the parts, and are manifested not only in the formation of acids in excess, but also in the formation of *abnormal* or *unnatural* acids in greater or less quantity. Hence we observe that the urine is highly acid, and that *lactic* acid* is eliminated in large quantities by both the skin and kidneys.

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* Uric acid is named an unnatural product because it is that by which nature relieves the system from effete animal matters. But lactic acid is a product of diseased or abnormal action, and is, therefore, of a different kind.—Liebig, Organische Chemie, p. 784.

When the body is exposed to the action of a cold, damp atmosphere, the function of the skin is impeded or suppressed, and consequently the blood would become seriously contaminated were it not for another wise provision of nature. We have abundant proof that when from any external or internal cause a particular function becomes impaired, it is compensated by increased activity in the functions of some other organ. Let us instance an example: the blind are endowed with such sensibility of touch and hearing that they can read and understand print by the mere feel of the letters, and their delicacy of hearing is so exquisite, that they are aware of dangers which, under greater obtuseness, they could not possibly perceive or avoid. When, then, the action of the skin becomes arrested, the kidneys immediately acquire much greater activity, and not only is the quantity of urine increased, but often under such circumstances found to contain principles not naturally part of its composition. These impediments, however, cannot exist for any lengthened period without sensible derangement of the system, complicated with changes in the functions of particular organs, and giving rise to disease.

We have already stated that acute rheumatism is essentially an inflammation of a special character attacking the parts about the larger joints. It is the white structures, as they have been named, which are most commonly selected by rheumatic inflammation for its location. Hence the internal surface of the synovial membrane* is almost always the seat of this inflammatory action.

We are not, however, to infer from these observations that the above are the only parts which suffer from rheumatic attacks. The muscular and tendinous tissues, together with the periosteum, are often affected. When the muscles become the seat of rheumatism, they are unable to contract from pain, and are extremely sensitive to variations in the atmospheric electricity.

The affected muscles swell, and are very irritable. Contractions of an involuntary character, or, to speak more correctly, involuntary efforts at contraction, are excited, but the will, acting in opposition, they are immediately checked, and slight convulsions apparently result.

When the inflammation has spread to the perioste this becomes thickened, its vessels distended, and a superabundant secretion is poured out, which, thickening and indurating between the bone and the periosteum, forms hard knotty deposits, very much resembling those painful swellings so familiar and so well known as "Nodes."

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* The synovial membranes are all *shut sacks*, entirely closed, and without any opening. The internal surface of the synovial membrane is the secreting one, and pours into the interior of the sac a sort of oily lubricating fluid, which diminishes friction, and renders the motion free and easy. The synovial fluid, in its natural condition, is a transparent viscid fluid, consisting of water, with about six per cent. of albumen, some extractive matter, and salts.

Neither is the skin or the subcutaneous cellular tissue exempt from rheumatic inflammation. The red appearance, the swelling, the heat and the pain give unquestionable evidence of their liability to implication in this most distressing affection. Further, the skin when so affected does not allow the electricity, which is always flowing from the centre to the circumference, to pass off; hence it collects beneath the cutaneous surface, which satisfactorily accounts for the very violent and peculiar pain that is felt in such circumstances.

It is, however, the inflammation of the synovial sacs as already described which produces the greatest pain and the most serious consequences. It has been already stated that inflamed surfaces have their activity increased; their secretions augmented, and not unfrequently vitiated in quality. Thus we often find that instead of the natural lubricating fluid, proportioned in quantity to the functions, we have an abnormal secretion greatly exceeding in amount that required for the ordinary actions of the part. This increase is attended not only by pain, but also by great difficulty, if not actual obstruction to the performance of the proper functions. One frequent and indeed most serious result of this kind consists in the pouring out of coagulable lymph. This is not only an unnatural secretion, but its *coagulation* gives rise to a solid deposit in the tissue, which obstructs the natural actions, and in the case of the joints impedes and in many cases completely prevents their motions.

The synovial sacs, when their interior has been the seat of rheumatic inflammation, become the subjects of similar deteriorations of function, and the synovial fluid no longer retains its mild, bland, lubricating quality. Hence stiffness, impediments, and even complete obstruction to the articular movements.

Treatment of Acute Rheumatism. In alluding to the treatment of acute rheumatism, I by no means contemplate entering upon anything like a complete or even lengthened therapeutical history of this form of disease. I shall, therefore, touch upon it only in such a general way as may serve to convince patients of the necessity of a strict observance of the rules laid down for their guidance, rather than with a view to direct the inexperienced practitioner or guide him in the application of those principles of treatment which the nature of the disorder requires.

It has been already stated that acute rheumatism is attended with a considerable degree of sympathetic fever or constitutional disturbance, while all the phenomena of active local inflammation are present in a severe degree. Blood-letting will naturally suggest itself as an essential means of relief. There are two modes of abstracting blood, namely, *general* and *local*. The first requires no small degree of consideration and caution; for rheumatic patients, especially those who live in towns, do not require, nor would the system bear active depletion. The second mode, even where the pain and inflammation are local, is not adapted to the case. Leeches may subdue the inflammation in a joint; but from the unsettled erratic character of the disease, we incur the risk, by such local measures, of repelling the poison and retaining it in the circulating blood, thus giving it a new and a more serious location. An injudicious abstraction of blood has not unfrequently proved the cause of such a misfortune, and the patient's life been thereby placed in imminent danger. The propriety of blood-letting, however, and the selection of the mode of abstraction, are questions exclusively for the judgment of the practitioner, and consequently require but little discussion here.

The evacuation next in importance to blood-letting is purging. Purgatives differ in their nature and properties, but still they act upon one or other of two principles, either by promoting the secretion of the mucous membrane, or by increasing the peristaltic motion of the intestines. To keep the bowels *open* forms a part of the antiphlogistic regimen, and in acute inflammatory diseases active purging is of great service. Two objects are gained by it; the stomach and intestines are freed from accumulated fæces, or other matters, which, by their bulk or their acrimony from mal-assimilation, might prove irritating, and at the same time depletion is carried on by means of the serous discharge which is produced from so large an extent of mucous membrane.

Colchicum is often prescribed in inflammatory diseases, and seems to have a specific action in both rheumatic and gouty inflammation. The preparations of colchicum have sometimes,—whether venæsection has been prescribed or not,—an almost magical effect in subduing the disease. Frequently, and indeed when most successful, (though that is by no means a necessary condition of their success,) they exercise some marked influence upon the stomach and bowels. Colchicum is very apt to occasion deadly nausea and vomiting, griping and diarrhœa, and when these consequences ensue, the inflammation of the joints often entirely subsides. At any rate, if the rheumatism does not give way when the stomach and bowels become thus affected, we may be certain that to push the colchicum further would be not only useless, but perhaps hazardous.

I believe that in proportion as the synovial symptoms predominate or mix themselves distinctly with the fibrous; —in proportion as the disease approaches in its characters to gout,—we may expect to be successful with colchicum.

Next to blood-letting as a remedy in rheumatism, and of vastly superior value upon the whole to purgation is mercury, especially when combined with opium. Many cases yield readily to the influence of calomel assisted by opium, and in what I have named the "fibrous form" of the disease, I think that calomel and opium are the remedies upon which, after sufficient bleeding, we may with the most confidence rely. It is this variety of the disease which most frequently extends itself to the membranes of the heart.

Dr. Hope has published an account of a particular mode of using calomel and opium in this disease, which is said to be so successful, that I cannot refrain from mentioning it. The plan is as follows :—" After a full venæsection, or even two, in the robust, but without any bleeding in the feeble and delicate, 8 or 10 grains of calomel, with a grain and half of opium, according to the age of the patient and the severity of the case, are administered every night, and followed every morning by a strong black dose sufficient to insure four or five stools at least. With this treatment is combined thrice a day, a saline draught containing from 15—20 minims of the wine of colchicum and five grains of Dover's powder. When the pain and swelling are greatly abated, if not almost gone, the calomel is omitted, or it is omitted sooner if the gums become at all tender. The opium, however, is continued to the amount of a grain or a grain and a half at bedtime, and in severe cases a grain also at noon is added, and the colchicum and the black dose are still given as at first." Dr. Hope considered it as a case of exception if the patient were not well in a week.

Dr Budd, in a clinical lecture delivered at King's College Hospital, says on the question of treatment :— " This, after treatment of various kinds at King's College Hospital, I find to be best under the form of large doses of alkalis ; it suggested itself to us from the large amount of acid in the system. I think it as successful, if not more so, than any other plan tried in University College Hospital. I usually prescribe the bicarbonate of potass (gr. xii. ad gr. xv.) with nitrate of potass (gr. v.) every four hours; or if we put it in technical language, it will be—

℞ Potassæ bicarb. . . . ʒi.
Potassæ nitrat. . . . ℈i.
Tere simul et in part iv. divide, detur i. horâ quartâ quâque.

I know no plan of treating acute rheumatic fever at all equal to this: it is quite remarkable how the symptoms yield according as the urine becomes alkaline. You will find, where many joints are affected, that the urine is extremely acid."*

In regard to the local treatment of acute rheumatism we cannot be too cautious when we remember the disposition to metastasis and the tendency to attack the heart.

When we consider that the joints most liable to attacks are those most exposed, such as the knee, wrist, and ankle, which are more exposed than the hip and shoulder, we cannot do better than take the hint, and encase the inflamed joint in medicated cotton wool and oil silk. Warm alkaline fomentations will also frequently afford great relief.

It may appear singular that I have omitted to mention electricity as a remedy in acute rheumatism; but I do not advocate its application in this form of the disease, in which we have to contend with acute inflammation.

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* Med. Circular, 1 Nov. 1854.

CHAPTER VIII.

CHRONIC RHEUMATISM.

I HAVE dwelt somewhat at length upon acute rheumatism, because in a very large proportion of instances the acute form is that in which the disease makes its first appearance, comprehending the most painful and excruciating period of its continuance; and in a large proportion of cases being the immediate antecedent to the chronic. The history of acute rheumatism forms, therefore, a necessary preliminary to the therapeutical consideration of the chronic. It is not maintained that the acute is a necessary or invariable antecedent to the chronic form, for there are many examples of chronic rheumatism making its appearance without having ever been preceded by fever, or even acute symptoms. Sometimes, however, chronic rheumatism is attended with symptoms so severe and painful that it may be said to differ in nothing from the acute, but in the absence of the sympathetic fever and the attending constitutional derangement.

Chronic rheumatism may be divided into two perfectly distinct and well-marked varieties. In the one there is a considerable degree of local heat, swelling, redness and pain, but the constitution does not sympathise, or only in a very slight degree. In this form the pain is greatly increased on pressure or by motion, and is much aggravated by warmth. It is also extremely obstinate and lingering, crippling the smaller joints, rendering them knobby, and causing distortion of form and position. The fingers assume an oblique direction, slanting as it were outwards; and it will be found that the corresponding joints of the two hands are affected exactly alike.

The other form is distinguished by the coldness and stiffness of the joints, which become rigid and incapable of motion. The pain in this kind is alleviated by friction and external warmth of whatever kind.

The local effects of rheumatism are not uniform in character, but vary in different cases. Pain and swelling have been already mentioned; but sometimes we have loss of sensation, wasting, spasms, palsy, and even complete paralysis. I have observed as a very constant, and indeed a very characteristic sign of rheumatism, a peculiar thickening of the tissue beneath the skin. This is attended by a good deal of hardness with a general swelling of the surface; and the disorder seems to advance or decline *pari passu* with this induration.

In the parts where these indurations exist, the skin, although not much raised, seems thicker, exhibits a peculiar sort of rigidity, and if we attempt to pinch it up it can only be done in thick folds; and when it has been pinched up into such folds it looks tumid, thick, and smooth. If more compressed it has a shining appearance, which cannot be produced in healthy skin. All this is owing to effusion, and the colour of these places is for the most part lighter and whitish, thus indicating the more immediate seat of the effusion.

The effect of stimulants on these places is very peculiar; for instance, the electro-galvanic current produces all round the spot that condition designated "goose's skin," while all the rest will remain quite smooth. These rheumatic effusions affect the sensibility of the skin in various ways. Thus the sensibility may be very obtuse to the touch, while the skin is highly sensitive to all kinds of atmospheric changes. The parts in which the effusions exist are not painful when touched, but are very sensitive to the passage of an electric current. They are also subject to particular feelings—as a sense of cold, heat, itching, &c. But of all the varieties of concomitants that attend upon rheumatic effusion pain is by far the most frequent.

The next, and a very common form of rheumatic effusion, is that into the subcutaneous cellular tissue. This occurs either in small circumscribed spots, or it may be spread over a limb, or the entire body. It is recognised as a slight swelling, the skin over it having a shining appearance, and not admitting of being pinched up into a fold.

The swelling is firm and hard, and only pits on pressure when it has been continued for some time. The margins of these effusions, where circumscribed, may be distinctly felt while the surrounding parts are soft and pliable.

The electro-galvanic current turns the surrounding skin red, that over the effusion remaining pale, and thus defining its extent.

Another variety of rheumatic effusion is situated in the muscles. In this condition the muscles are stiff and unyielding, gradually decrease in size, and feel like hard tendinous bands. The muscular effusion is generally insensible. The power of contraction is much diminished in consequence of the inability of the muscular fibres to contract.

If we endeavour to excite contraction by the passage of an electro-galvanic current, the muscles will remain perfectly passive if the effusion is considerable, thus forming a striking contrast to that form of paralysis proceeding from an affection of the nervous system.

The muscular powers become impaired in various degrees—from mere stiffness to total loss of voluntary motion. Passive motion is sometimes possible, though it may be restrained by the acute pains which it causes in the joints.

The passage of an electro-galvanic current causes a feeling of warmth, and the gradual absorption of the effusion—the muscles recovering their natural condition *pari passu* with the absorption.

The last form of effusion is that which takes place beneath the periosteum. This, however, seldom occurs alone; the other structures, also, being most generally affected. If such complications are not present, or having been present have been removed, small oval swellings may be felt on the subcutaneous aspect of thinly-covered bones. There is only one symptom distinctly referable to periosteal effusion, viz. pain, which is always very severe; and these effusions are exquisitely sensitive to the passage of an electro-galvanic current. This increased sensibility is strictly confined in its extent to that of the effusion.

Periosteal effusion ranks among the most violent and obstinate of rheumatic disorders. It often assumes the form of neuralgia, or of deep-seated disease of the bone, and requires the most energetic and persevering treatment to effect its absorption. I have not seen an instance of exfoliation resulting from these rheumatic nodes. Other structures and tissues may become the seat of rheumatic effusions, as, for instance, the neurilemma or sheath of the nerves. Effusions also take place into the serous cavities; but as such are productive of a class of phenomena different from those of the effusions which have been named "rheumatic indurations," it will not be necessary to enter upon them in this place.

There is, however, an affection of the joints, attended with effusion, and which, whether the effect of rheumatism in its acute or in its chronic form, is of the highest importance. This is named "articular" or "chronic articular" rheumatism. It mostly attacks the smaller joints of the hands and feet, indeed in preference to the larger ones of the same parts. It is then called "rheumatic gout." The pains of the affected joint are of the most racking description, greatly aggravated by changes of weather and by heat, especially of the bed at night. The pains are not increased by pressing the articular surfaces against each other. The joint, however, becomes stiff, its motions are impeded, and the muscles around it become wasted.

No part of the body is, under the circumstances, more frequently diseased than the membrane which secretes the synovia by which the joints are lubricated, and which forms a shut sack, having no external opening.

When a joint is distended with fluid, we generally find that there is pain, and also inflammation, which cause an increase of the secretion from the surface of the synovial membrane. Cases do, however, occur in which a joint is distended from an increased quantity of fluid collected in its cavity unattended by pain or inflammation. It is presumed that this proceeds either from the diminished action of the absorbents, or from the increased action of the secreting vessels.

Inflammation of the synovial membranes, when the system is under the influence of rheumatism, is a constitutional affection. It is very often caused by cold, and attacks the knee more frequently than any other joint, because it is the most exposed to the influence of the weather. The inflammation, when confined to a single joint, is generally more severe, and of longer duration, than when several in succession become affected.

When the inflammation has subsided the fluid is absorbed, and in most cases the joint returns to its natural size and mobility, though in some instances stiffness and swelling remain. In this latter case the patient is very liable to a return of the disease, either from exposure to cold, too much exercise, or derangement of the general health.

A question here arises: Are rheumatic effusions the result of pure inflammation, or of impeded perspiration? The first symptoms lead to the inference that inflammation is the cause; but the subsequent course of the complaint warrants a different conclusion. The theory which refers the depositing of fluids beneath the skin to the checking of its excretions, is evidently too mechanical to be consistent with known principles, and certainly is derived from erroneous notions of the process of secretion. But there is a function which, whether it be in reference to inflammation or secretion, deserves our attention, and that is the nervous energy.

Every appearance of change in the body, whether physiological or pathological, commences with an effusion at first necessarily fluid, which is carried along by the blood from which it is secreted. This formative fluid exudes through the coats of the vessels. This is the first mechanical process of nutrition as well as congestion and inflammatory effusion; and indeed whatever fluids pass from the circulating medium into the surrounding structures. This exudation of a portion of the blood through the coats of the vessels is common to all exhalations. The question then arises, what causes the fluid to escape from its natural channels? It may happen either from some alteration in its consistence, or its composition; from congestion, debility, or from some change in the texture of the sides of the vessels. It is well known that these are porous, that the external and middle coats are composed of fibres, and the inner one of a thin delicate serous membrane. The fluid, of course, escapes more easily when the porosity is increased; and a membrane composed of fibres must naturally be more porous when distended, the spaces between the fibres becoming larger. Therefore, in every case where the blood is not altered, effusion is preceded by a distention of the vessels. Henle observes, "Increased contraction of the capillaries causes paleness, and restricts the escape of the plasma; atony and paralysis of them produce redness and an increased collection of the plasma;" and he comes to the conclusion that paralysis of the capillaries is the principal cause of congestion, inflammation, and effusion. It cannot be denied that the vessels contract, since Schwann saw them contract beneath the microscope on the application of cold; and Valentin has also observed the same result from irritation of the nerves supplying them. The contraction of the capillaries is induced by the effects of temperature; mechanical, chemical, and electrical stimulants. This is proved by the experiments which have been made with solutions of salt, sal volatile, cantharides, and alcohol, on the veins and capillaries; contraction of the veins has been produced by pinching them with forceps; and I have often seen distended vessels contract on the application of an electrical current, the part stimulated becoming pale. I have frequently produced, by the stimulus of electricity in the cutis and contractile tissues, cutis anserina, which results from the same psychological impressions that give rise to increased contraction in the muscles. If, as it appears by this, the vessels are affected by the same excitants as the muscles, a great difficulty opposed to this theory will be removed.

The next question is, do effusions arise from relaxing, and disappear under the influence of contracting, causes? This is known to be the case in inflammation—for example, a contusion is followed by a reddish-coloured swelling and inflammation, which subsides on the application of cold. We have the same again after frost-bites; the first visible effect of cold is that the part becomes of a dull red colour, in consequence of a diminution of the quantity of blood conveyed by the arteries, and a stagnation of it in the veins; if the cold be continued, the blood is gradually expelled by contraction of the tissues and the part becomes livid and pale. Sudden alternations of temperature cause redness of the skin and swelling, owing to the distention or relaxation of the vessels, and stimulants are required in order to excite them to contract.

As dilatation of the vessels is caused by relaxation, and removed by stimulation, so is it also in rheumatic effusion. The proximate cause is some influence which weakens or paralyses in some part the nervous energy, results which follow the continued abstraction of heat. But if the products of rheumatism are formed, they can only be removed by such means as stimulate the nerves of the parts affected, so that contraction of the vessels supplied by these nerves ensues as a secondary consequence. These remedies act either directly or indirectly. Those which act directly are mechanical stimulants, as shampooing, rubbing, passive and active motion, and electricity; those which have an indirect influence are stimulating applications, the effect of which is explained by the reflex function, though we must admit that some advantage is derived from the local application.

The analogy of the mechanico-physiological process in other effusions proves that rheumatic induration proceeds from a diminution of the "vis nervosa."

If we come to the conclusion that rheumatic effusion is the effect of the disturbance of the nervous system, and consider rheumatism as a peripheric disease of the nerves, it is not difficult to explain, why in rheumatic affections symptoms of apparent disease of the nerves, as paralysis or pain, should be superadded to such an extent as scarcely to bear any proportion to the exciting cause; whilst the rheumatic affection is considered only as the result of altered secretion and impeded perspiration, and not as the product of the change which has taken place in the irritability of the nerves. This view will also explain why rheumatic disease continues until the exudation is absorbed; for the effusion either mechanically obstructs the influence of the "vis nervosa" on the muscles or brain, or shows the degree of relaxation of the vessels and the diminished irritability of the nerves upon which the vessels are dependent.

CHAPTER IX.

TREATMENT OF CHRONIC RHEUMATISM.

We arrive then at the conclusion that the general principles of treatment must be regulated and arranged much in the same way as in acute rheumatism—the same remedies, with the exception of blood-letting, being applied, only so modified as to suit its different varieties. In those chronic forms in which there is considerable stiffness and swelling arising from some constitutional affection, it is first of all necessary to attend to the general health, to promote by gentle exercise a moderate degree of perspiration (which it must be observed often proves extremely difficult as the skin is usually dry and harsh), and the patient must avoid raw fruit, acids, pastry, or whatever is likely to cause acidity of the stomach, to which there is a strong tendency. The bowels should be regulated by warm aperients. A combination of the wine of colchicum with the hydriodate and bicarbonate of potash will act very beneficially.

The application of electric currents to joints which are stiff and distended with fluid will generally render them supple, and effect the absorption of the fluid.

Benefit will also be derived from vapour and sulphurous baths, inunction of iodine, rubbing, shampooing, and encasing the affected joint in medicated wool and oil silk.

Electro-Galvanism.—We have still, however, a remedy in reserve, which has proved the most powerful and the most effectual means yet resorted to for the cure of chronic rheumatism. The remedies which have been previously mentioned were formerly the only ones known capable of controlling rheumatic symptoms; but now we have in electro-galvanism a power compared with which all the others must be considered as merely subsidiary. The inveterate obstinacy of chronic rheumatism, its utter defiance of art, and the wretchedness and misery which it entails, are well known.

It has been already stated that I do not propose electricity as a remedy in acute rheumatism; but in the chronic form of the disorder it may be resorted to without the slightest hesitation, and its employment will in no way interfere with the administration of any other remedies which may be judged necessary. "In the chronic form," says Horne, "or after the stage of excitement has been subdued in rheumatism, gout, sciatica, lumbago, and other painful affections of the muscles and nerves, the greatest benefit will be derived from the electro-galvanic fluid after other remedies have completely failed; and should the operation have been delayed even long after the chronic state has arisen, its use will be found invaluable," as exemplified by the following case :—

H. B., after having been exposed to severe cold, was attacked with symptoms of acute rheumatism; during the first fourteen days the febrile symptoms ran so high as to give rise to serious apprehensions. A diaphoretic plan of treatment was pursued for five weeks, when there remained swelling and pain only of the wrist and finger-joints of the right hand. The skin often appeared red, could not be moved over the parts beneath, and became very painful when exposed to the air. The patient also complained of pain and stiffness in the loins; he was frequently deprived of sleep, and the only relief he obtained was from the perspiration produced by violent exercise. Under these circumstances he came under my care. I commenced by passing a gentle electro-galvanic current through the affected parts every other day for a month. The pain in the loins first disappeared, but that in the wrist continued a few days longer. During the last fourteen days the current was applied only along the outer side of the right wrist to the thumb; after which the hand could be freely moved for the remainder of the day, and he was discharged cured.

The above case shows the transition from the acute to the chronic form, and also the obstinacy of the latter, and the great tendency which sometimes prevails to pass back into the acute. It will be observed, that notwithstanding the relief to a certain extent afforded by medical treatment it proved but temporary, the disease soon resuming its original severity.

The following case will afford an illustration of the influence of galvanism upon rheumatic induration.

An unmarried lady, of a nervous temperament, had been for several years subject to attacks of rheumatism, which generally commenced with acute fever lasting from two to three weeks, and then terminating in a chronic rheumatic affection. I was sent for to attend her in one of these attacks. In a couple of days the fever abated, but the pains continued with undiminished violence. The right shoulder and arm were very red. On the posterior surface of the shoulder there was an extensive induration in the cellular tissue, very evident from the shining bluish-red colour of the skin above. The swelling was firm, and painful when pressed, and the skin could not be pinched up. Motion was so crippled by pain and loss of power, that the patient was obliged to support the arm in a sling, and lift it with the other hand when any movement was necessary. The pain was exceedingly violent, but most severe at night. I passed a weak electro-galvanic current from the shoulder to the hand. This caused acute pain in the induration, which, however, ceased entirely when the current had been applied a short time.

A few days later she felt much depressed in consequence of erratic lancinating pains; but these, on passing an electro-galvanic current, soon subsided, the induration becoming softer and the movements of the limbs freer.

A week later the patient was able to use her arm freely and without pain, the nights were quite tranquil and composed, and there was not even a trace of the induration to be seen; in fact, the complaint was completely removed.

This case is interesting, for the patient had been the subject of several attacks previous to that which forms the matter of the present history. She had suffered intensely for twelve days, notwithstanding all the ordinary remedies.

The application of the galvanic current for eight days sufficed to effect the absorption of the induration, which, under the ordinary plans of treatment, would have required at the very least from six to eight weeks. It may, perhaps, be urged that the remedies given in the first instance were the *real* means of cure: the following case will be found in no way open to any question of this kind.

A young man, aged nineteen, a smith by trade, whose health had been always remarkably good, caught a severe cold, and suffered, in consequence, from swelling and violent rheumatic pains in both ankles. The pain shifted from one joint to another, and was attended with a bluish-red swelling. After taking vapour-baths for fourteen days the pains left the joints, but the ankles continued in the same state as at first, and at the end of a month, under the impression that he had obtained no relief, he discontinued them.

When he came to me he could scarcely walk, nor indeed stand without great difficulty, in consequence of acute pain. The toes were rigid, and the ankles swollen. I applied an electro-galvanic current to the swelling, and in five or six minutes the pain entirely ceased, nor did it return for three hours, and was then less acute. This treatment was continued for a month, when the patient was perfectly cured, and resumed his occupation.

The following is a brief history of a case which came under my care, after a long period of painful and distressing suffering. It was communicated to me by the patient herself, and I have published the detail as nearly as possible in the patient's own words:—

" About thirteen years ago—ten years before my application to you,—I became afflicted with a very severe and obstinate spinal complaint. The agony which I endured was almost intolerable. A number of medical gentlemen were consulted, but all their efforts to afford me relief completely failed. I grew worse from year to year, and I at last became paralysed from the hips. My legs were drawn up, so that my knees nearly touched my chin, and I might be said to be drawn up double. I was in this condition, when about three years back I was advised to place myself under your care, and I am thankful to state, that by your treatment I have continued to improve in health ever since; and I feel quite happy in acknowledging that I am now comparatively free from pain, and what I was incapable of before, able to walk about."

I have given this case nearly in the language of the patient herself; I prefer this natural brevity and simplicity of description to all technical parade. It would, indeed, be difficult to convey by any description the actual condition of this patient when she first applied to me; I shall not, therefore, attempt so hopeless a task. Some idea may perhaps be formed when it is recollected that she has been three years under treatment, and her own account of her progress and present state is quite sufficient to show the difficulties that had to be encountered. The treatment consisted chiefly in the application of electro-galvanism, medicines of course being administered to accomplish particular objects, and the result has been more happy than could have possibly been expected.

Rheumatism, it has been already stated, is not only a very severe disorder, but also frequently proves a very tedious and lingering one, causing a great deal of misery and suffering to the unfortunate patient. In illustration I shall detail the history of the following case, given up to a certain period in the words of the father, and I think it will be allowed to stand unparalleled for obstinacy and severity.

In the year 1844, E. H., then only eleven years old, was attacked with the *brow* ague, causing acute pain in the head and a stiffness in the neck. A medical gentleman was consulted, but no relief obtained. In the summer of this year she went to Alderney for the purpose of bathing. She derived some benefit from the voyage and sea air, and she returned home generally much better, but the stiffness in the neck still remained. In the spring of 1845 her knees and ankles were very much swollen, attended with great weakness and pain. Her medical attendant pronounced it weakness from growing too fast, and prescribed quinine, &c. The weakness continued to prevail—sometimes more, sometimes less severely—through the spring and winter of the years 1845, '46 and '47, the neck and arm being completely fixed during these lengthened periods. During the years 1848, '49 and '50 she felt comparatively well, excepting the stiffness just mentioned. But in the winter of 1850 the stiffness in the neck, which had been somewhat relieved, increased very much, and in the spring of 1851 became painful, and implicated the whole of the back along the spine. Quinine was again administered on the principle of weakness. She now left home again for a change of air, and in a few weeks gained strength; but on her return the swelling and pain greatly increased, causing a degree of inertness and partial lameness—in fact, the whole system was affected.

In the August of 1851 she went to Guernsey, where she gained strength, and on her return home she found herself much better ; but in October the disease had evidently become more fixed, so much so that she was confined to her bed in November, and remained so for some weeks; and for three months she got up for only a few hours each day. Even then she could not move without help; one of her feet was turned in, or to express it more appropriately, doubled at the ankle. Another medical gentleman was now consulted, who said that she was afflicted with a kind of rheumatism, but that it depended chiefly upon weakness, and, therefore, prescribed tonics, warmth, and good living.

In the spring of 1852, being still quite lame, she went into Kent; she was then advised to go to Brighton for the benefit of sea-bathing, for which purpose she went there in June. But the medical gentleman she consulted objected to the bathing in consequence of her being attacked with diarrhœa. During her stay at Brighton the pains greatly increased, especially when the weather was stormy, and were most intensely aggravated when the storms were accompanied by thunder.

She returned to Kent in the latter end of July, where she gained some strength in the autumn, but as the winter set in the symptoms rapidly increased, and became much more severe, so that she could not move in the least without help.

In the February of 1853 she had a severe attack of influenza, accompanied with a bad sore-throat; as she was recovering from which she had an attack of scarlatina, that confined her for some time to her bed. During the continuance of scarlatina she was almost completely relieved from the rheumatic pains, and for a few days could even walk up and down stairs. But no sooner had the scarlatina left her, than the whole system became so severely affected by rheumatism that she could not even turn in her bed.

Upon this occasion a medical gentleman of great experience was consulted. He seemed thoroughly to understand the nature of the case, and with great feeling announced his fears that no hope of eradicating a disease of so long standing (nine years) existed, and indeed his apprehensions that she would suffer through life. He, however, adopted a palliative system, and seemed to take a most lively interest in the case. After several weeks this gentleman recommended her to be removed to Hastings for the benefit of bathing, observing that the milder climate, assisted by the sea air, might alleviate in some degree the excruciating pains. He, however, held out no hope whatever of cure. When asked whether he thought galvanism likely to be beneficial, he expressed very *great doubts* of any *such* results. This is a circumstantial and precise, though in some degree condensed, account of the written history of this case as I received it from her father.

On the 10th May, 1853, she was placed under my care. At this time she was wholly incapable of the slightest exertion—not to say movement. She was obliged to be carried from chair to chair, and was totally unable to turn in bed. I attended her for about a week, during which period I directed her to take some medicine to prepare her for the electro-galvanic treatment, with a view not only to facilitate its operation, but also more precisely to ascertain the extent of the disease. This object attained, she was carried in an arm-chair to my residence. In ten days, after a few medicated electro-galvanic baths, she was able to walk with a little assistance to my house. In a short time the swelling of the knees and ankles gradually subsided, and the muscles became much stronger.

When I first saw this patient the whole system was deeply implicated, but by appropriate electro-medical treatment, the symptoms which seriously threatened her existence were gradually subdued, and at length overcome. Indeed, I cannot better describe the result than in the unvarnished description of her parent above alluded to. "The rheumatic affection," he observes, "in the different joints, knees, ankles, &c., which had been dreadfully swollen and distorted, the stiff neck so firmly fixed on one side, both the arms positively crooked, these have one and all been nearly restored to their former natural state; the swellings are nearly all gone down, and there is every reason to hope she will shortly be restored to the free and full use of those joints and muscles which have for so many years been stiff, painful and crippled. She can walk upwards of a mile, and her general health is so much improved that she now sleeps soundly at night, free from those excruciating pains which for so many years disturbed her rest, and were unnerving the system and wearing out both body and mind."

This young lady was three months and a half under my care, when she left London completely recovered; and she is now (December, 1854) quite well, in the enjoyment of excellent health, and capable of walking a distance of four of five miles without the least inconvenience.

The history of this case may give the reader some slight idea of the state of misery from which this patient suffered for a period extending over nearly ten years. Various modes of treatment and change of climate had been tried without advantage.

It may appear singular that electricity was not sooner resorted to; but it must be remembered that in the earlier periods of her illness its curative powers were not so well known, nor its management or modes of application so thoroughly understood as they now are. This, however, will not vindicate the doubts and objections made. But when, at a later period, every remedy had been tried in vain; when the hopeless state of the patient was open to observation, and every means that could be suggested had been adopted and failed of success; the proposal to try the electro-galvanic treatment was received with coldness, and met with such doubt and hesitation, that had the objecting parties prevailed this unfortunate young lady would have been consigned to her fate, without even a trial of the means which happily restored her to health. These facts, if properly considered and duly estimated, inculcate some wholesome lessons for the future guidance of the practitioner. First, not to object to means of the powers and capabilities of which he is perfectly ignorant. Secondly, in desperate cases to remember the admirable axiom inculcated by Celsus:—"De quo dubitare in ejusmodi re non oportet; satius est enim anceps auxilium experiri, quam nullum."

Rheumatism, whether in the acute or chronic form, often subsides, leaving the patient free from all complaint, and feeling as if no disease whatever had prevailed. So fortunate a termination is not, however, the invariable result. Sometimes pain remains in one of the joints, causing inability of motion, increasing and decreasing in proportion as the degree of pain impedes the articular movements.

In other cases there remains a degree of stiffness, not, however, amounting to organic impediment, but so far interrupting or impeding the movements as at times to be not only inconvenient but truly distressing. Such cases are thoroughly cured, in a comparatively short space of time, by the electro-galvanic current, of which I shall present the following as examples.

Mrs. H., aged forty-five, a healthy-looking woman, having been previously exposed upon several occasions to severe cold, was attacked with lancinating pains in different parts. In the month of January she had an attack of acute rheumatism in the left shoulder. The joint became stiff and subject to severe lancinating pains at night.

On the 20th of May she came, accompanied by her medical attendant, to consult me. She appeared worn out. She could not move her elbows either forwards, backwards, or sideways, nor could she lift her hand to her forehead. The slightest attempt to move the arm brought on violent pain in the shoulder. Even passive motion, pressure, change of weather, or cold, equally caused pain. A weak current was applied for several days in succession, which allowed a freer motion in the joint, and moderated the very great sensibility to the state of the weather.

June 21st. Eighteen applications had been made. The arm could now be moved more freely, and the hand raised to the top of the head, and backward as high as the waist. The shoulders continued to feel painful when moved; and the patient could not hold needlework sufficiently firm in her left hand to be able to sew. The effort to do this caused so much pain and suffering as to render it impossible.

29th. No complaint of pain. The arm felt strong; its movements were perfectly free and unconstrained, and she could knit and sew for hours together without any difficulty.

The following is another example of the relief afforded by the galvanic current in rheumatic pains attended with stiffness. These cases mostly arise from exposure to cold when overheated; and when the attack has been subdued, or given way spontaneously, relapses are frequent upon the slightest exposure.

A married lady, aged forty, about two years before my seeing her, received a sudden chill when much heated by very fast walking. On the following evening she was attacked with severe pain, swelling, and stiffness of the limbs. This attack lasted four months, and then subsided, leaving her, however, very much debilitated.

Three years ago she again caught cold, her limbs became affected, and were gradually getting worse. The hips and loins felt powerless, and she had constant pains in the legs, with a sensation of numbness and debility.

On the 22nd September she was galvanised for twenty minutes, after which she walked home with much less difficulty.

This plan was pursued for three months (the current being applied once or twice a week), during which period she continued steadily to improve, and gradually lost the pain in the loins, and that feeling of debility which distressed her so much. A little stiffness in the limbs remained for some time, but this at length gave way, and she recovered perfectly.

It is often very difficult to define the line separating some rheumatic affections from certain paralytic ones.

I have upon several occasions found myself in a dilemma of this kind, and others I find have experienced similar difficulties. Thus, Dr. Golding Bird observes, "a gentleman consulted me with nearly complete paralysis of motion of the left arm, sensation being pretty perfect, no pain whatever in moving the limb. During a cold winter he had been in the habit of sitting at his desk with the right side of his body roasting by a large fire, while the left was chilled by blasts of cold air from a frequently-opened door. Gradually pain and stiffness appeared in the left arm, but no swelling. The pain gradually vanished, and the limb was left palsied. Other remedies proving useless, the electro-galvanic current was applied. After a few weeks he quite recovered."

Sir Charles Bell also, in his work on the "Nervous System," says, "a physician paid me a visit who had come up from the country by the mail, and had fallen asleep in the night-time, with his cheek exposed at the open window to the east wind. On the morning of his arrival, when preparing to go abroad, he found upon looking into his glass that his face was all twisted. His alarm gave more expression to one side of his face and produced more horrible distortion. I never saw distortion more complete." "I have at present," says the same authority, "a young lady under my care who has paralysis of the face from the same cause, and who has also received great benefit from galvanism."

I have had two cases under my care which were brought on through falling asleep in a railway carriage with a half-open window. In both there was pain and stiffness in the side of the face, followed by paralysis of the facial nerve; the other side was exceedingly distorted from the antagonist muscles becoming palsied. Sensation was perfect; for in all these cases the seventh pair of nerves are alone affected. The galvanic current was applied in both cases, and quickly succeeded in again placing the paralysed muscular fibres under the dominion of the will.

When effusion takes place into the synovial sac, nature, as may be readily imagined, makes an effort to absorb the effused fluid. But this attempt is not always successful, and having effected a partial absorption, that is, of the more fluid parts, the synovial membrane becomes thickened and gristly. Hence, rigidity, stiffness, and total inability to move the joint.

The knee is more frequently subject to these rheumatic synovial effusions than any other joint. Where such effusion exists the joint becomes swollen, stiff, and rigid; its motions are impaired, and in some instances completely suspended. The following cases will, perhaps, afford the best notion of this form of rheumatism.

Miss A., aged eighteen, of fair complexion, and apparently in very good health, had an attack of acute rheumatism in the left knee, which was treated with calomel and opium, &c.—but the patient progressed very slowly towards recovery. When she consulted me, she was suffering from severe pain, and could walk but a very short distance. The knee was swollen from enlargement of the internal condyle of the femur, and from fluid in the joint. The leg was extended, and could be moved only with difficulty.

Pressure upon the internal condyle caused some slight degree of pain, and the tendons behind the knee were rigid and stiff. The patient's sleep was much disturbed by the violent pain which extended from the knee to the ankle.

After ten applications of the galvanic current the patient was able to walk a tolerably long distance; the pain had subsided except after walking, but even that which was then felt passed away after a little rest. The knee was reduced in size.

After forty applications the patient was able to take a long walk without experiencing any return of pain. The joint was submitted to passive motion without causing the least pain, though before, passive motion however carefully attempted, produced intense pain. This patient continued under treatment a few weeks longer, and her recovery was then complete.

A large robust man, of vigorous constitution, and about fifty years of age, had been, during a period of three years, suffering from pains in his limbs, and swelling of the right knee. The patient could move about with the aid of a stick, but this brought on most severe pain. At night he suffered from acute erratic pains in the knee and leg; and about the middle of the shin-bone there was a hard swelling about the size of a crown-piece.

A galvanic current was passed through the parts affected, and after a few applications the patient could tread more firmly and without pain. The nightly pains gradually diminished in severity, and the swelling in the knee became softer and less tense.

In the third week the swelling of the leg had subsided altogether, and the nights were free from pain.

The treatment was continued for several weeks, the patient gradually losing every trace of pain, and the swelling of the knee subsiding, he was then able to increase the length of his walks, and considering himself perfectly well, the treatment was discontinued.

The two last cases are clearly instances of effusion into the joint. Effusions of this kind are extremely difficult to remove; they completely cripple the patient, rendering the limb stiff and useless, and often wearing him out from pain. The value of electro-galvanic currents has been fully proved in promoting absorption of the effusion into the joints, even after all the usual remedies have completely failed to afford relief.

There are two other varieties of rheumatism, viz., lumbago and sciatica, which, though they do not often assume so decidedly the acute character as those which have been considered, yet they are frequently very obstinate and difficult of cure. In lumbago the pain is sometimes so severe as to confine the patient to bed, and the slightest motion causes excruciating agony. In sciatica the pain is intense, beginning at the hip and shooting down the outer side of the thigh and leg to the foot.

The following cases may serve to give some notion both of its occasional severity and the cure.

A thick-set muscular man, seven-and-twenty years of age, suffered from great stiffness and acute pain in the back and shoulders, which became so severe that he was obliged to leave his employment. He was bent forwards, and walked with very great difficulty, and the attempt to sit down brought on violent pain.

The back and both the shoulders were galvanised every day, and after the fourth application the pains in the shoulders were entirely removed.

At the end of a fortnight the patient could stoop, raise himself up again, and perform all the ordinary movements freely and without pain, when he was discharged cured.

A man, forty years of age, who had enjoyed good health, was obliged to work in a room very much exposed to cold draughts of air. Some weeks before he applied to me he was attacked with a severe pain, extending all over his loins, with dull shooting pains in his bones, which became worse at night when in bed. He was unable to stoop, walked with the greatest difficulty, and had but little sleep.

Electro-galvanic currents were applied, and after the third application he was free from pain.

At the end of the first week he only complained of some difficulty in stooping. The application was continued for another week, when he was discharged cured.

CHAPTER X.

RHEUMATIC PARALYSIS.

Paralysis may be considered as consisting of two distinct varieties, one of which has its seat in the brain, or some portion of the nervous system; the other, in the muscular tissue itself. We have already explained that there are two systems of nerves—a motor and a sensitive. If the nerve be unable to transmit the impulse, the muscle will remain at rest, and no movement will take place; but supposing the nerve does transmit the motive impulse, and yet no muscular movement follows, it is evident that the excitability of the muscle has been impaired, deranged, or from some cause or other suspended. This latter is, no doubt, the condition in rheumatic paralysis. In ordinary palsy, the cause is in the nervous system; in the rheumatic form, it is in the muscular. It is chiefly the latter which will form the subject of the following observations.

No class of diseases exists in which the powers of electro-galvanism have been more extensively or more severely tested than in rheumatic paralysis; and indeed we may also include paralysis arising from nervous derangement, whether originating in congestion, or any other disorder of the nervous tissue. The application has generally greatly relieved the complaint, even if a perfect cure has not been effected, in which latter case some organic disease of an irremediable nature generally proved the opposing cause.

Partial paralysis is very apt to occur in certain parts of the frame, from the position of the nerves rendering them obnoxious to deranging causes. Among its more prevalent forms, we may rank facial palsy, not only from its greater frequency, but because of its formidable character, and its causing more alarm and anxiety to friends, and even the medical attendant, than the conditions which give rise to it really warrant. Electricity in such cases often proves of the greatest utility, enabling us to keep up the process of nutrition, and an active excitability of the muscles, during the temporary affection of the nerve.

Paralysis then may proceed either from congestion or some other cerebral mischief. Exposure to cold is also a very fertile source of rheumatic paralysis. Another cause is to be found in certain metallic poisons, those of lead for instance; and it may also proceed from exhaustion and enervation. All these cases are benefited in a greater or less degree by electricity. A very singular instance is mentioned in the Haarlem Transactions. The case of a patient is there related, who being palsied, *recovered the use of* his side, after receiving a hundred shocks from an electric eel. But a still more extraordinary and interesting history is given in the Medico-Chirurgical Review. A paralytic individual happened to be on board a vessel in the Atlantic; the ship was struck several times by lightning, and many of the crew experienced strong electrical shocks upon each occasion. Among the passengers was a man suffering from paralysis in both his lower extremities; he had been in this state for fully three years. At the time of the electric discharge he was lying in his bed, but immediately after a few of the shocks he became convinced of the capability of sensation and motion in the paralyzed limbs. He was enabled to rise, and was soon restored to the perfect use of them. The cure in this instance proved a permanent one.

When the operating cause which has brought on the complaint ceases to act, or its activity has been suspended, the electro-galvanic current cannot act injuriously; but on the contrary, in the great majority of instances, it will afford decided relief. In cases of long standing, improvement, as might naturally be imagined, proceeds but slowly, in consequence of the newly-deposited tissue, though it has become organized, never having contracted at the will of the patient.

In speaking of the eminently-successful treatment of paralysis by electro-galvanic currents, I do not, of course, include those instances in which the palsy has been caused by and depends upon organic changes;

the substance of the brain itself, the spinal cord, or the nervous tissues. We must also exempt tumours, and thickenings of the bones of the skull, and of the spinal column. Such causes are, generally speaking, beyond the reach of art. But where paralysis is the result of injuries affecting the motor nerves, of the rupture of vessels attended with extravasation of blood, or infiltration of the cerebral mass, or the nerves, electricity affords a powerful auxiliary, and confers great benefit: in fact it prevents that atrophy of the muscles which results from inactivity. It can therefore be regarded as a direct curative, only when the cause has been removed, and the palsy remains as a mere local affection.

Electricity restores the excitability to palsied muscles, and promotes nutrition; and its curative influence is rendered manifest by the reappearance of the electro-muscular sensibility, the increase of the temperature of the part, and the evidently increased nutrition and growth of the paralyzed muscles. We next observe the return of electro-muscular contractability, and lastly the power of voluntary motion—a power which has been previously wholly suspended.

Of all the remedies which art has placed at our disposal, there is none that will bear even comparison with electricity in the treatment of those forms of palsy which originate from rheumatism and from poisoning by lead. In both these forms, a cure has been effected after all other means had been repeatedly resorted to in vain. In atrophy of the muscles, too, the electro-galvanic current will arrest the changes which take place in the structure and organization of the muscles. The electro-galvanic current, it must be remembered, acts as a stimulant, and, under certain circumstances, even as an irritant; and indeed, under proper modifications, it may be made to produce precisely the same effect as either of these agents, no matter whether they be organic, inorganic, or chemical. When acting upon a muscle, or the nerve connected with a muscle, contraction of the muscles, as has been already stated, is produced; and this takes place equally, whether the irritant be applied to the muscle itself, or to the nerve. Nor is it necessary, in the latter case, that the nerve be connected with the brain or the spinal cord, for it takes place equally, whether the connection be preserved or separated. Now the great and very important difference between electricity and other stimulants is this—electricity acts upon all the nerves of special sense, whereas stimulants influence some of them only. Besides acting as a stimulant to the nerves and muscles, it exerts a similar action upon the spinal cord, the organs supplied with fibres of organic life, the blood-vessels, the lymphatics, and the skin. Its more powerful effects are upon the nerves of special sense, and the skin; its influence upon the latter is principally owing to its electro-chemical effects, by which it induces electro-chemical decomposition.

Electricity is applicable in all those cases in which irritants are indicated; and, like them, must be adapted, not only to the case, but also to the individual. Like stimulants, therefore, it is contra-indicated in all cases of acute inflammation, fever, and congestion. But while we thus restrict its use, we must assert its superiority over all other kinds of irritants and stimulants; first, because of the facility and precision with which it can be directed, and its action confined to any particular part; secondly, on account of the power we have of regulating the intensity, increasing or diminishing it at pleasure, according to the necessities of the case; and thirdly, because we can immediately interrupt, renew, or stop the electric action, as may be requisite.

RHEUMATIC PARALYSIS OF THE FACE.

Exposed as the face is, and considering its numerous muscles, we can readily imagine that it should often be the seat of rheumatic paralysis. This affection is almost always attended by rheumatic effusion, and is mostly confined to the branches of the facial nerve. Sir Charles Bell showed that these cases, instead of arising from apoplexy, according to the received notion, had their origin in the functional disturbance of a motor nerve. It is a well-ascertained fact, that cases of this kind arise from organic affections of the brain or of the facial nerve itself, and they have been known to depend upon affections of the canal through which this nerve passes.

The rheumatic effusion acts as a preventive of the muscular motions, and obstructs the passage of the *vis nervosa.*

In 1852 I was applied to by a lady about seventy years of age, suffering from paralysis of the right side of the face. She had been exposed for some time to a cold current of air, and on the following morning she perceived that her face was very much distorted. She thought the effect would soon pass off, and gave herself little uneasiness in consequence. In this, however, she was disappointed, for the distortion increased, and she then consulted her medical attendant. She received little benefit from the treatment, and under these circumstances applied to me. When I saw her, the saliva flowed incessantly from one side of her mouth, causing a great deal of inconvenience, and the same thing happened when she attempted to swallow any fluid. The lower eyelid was everted, lying on the cheek, completely exposing the eye-ball, and causing a great deal of irritation as well as disfigurement. The upper lid and eyebrow hung down over the eye, and her whole appearance was most distressing. As she had been subjected to active medical treatment, I at once began by passing a gentle electro-galvanic current. After the first week the improvement became very evident. At the end of three weeks, as every indication of the complaint had disappeared, the application of the current was discontinued for a week, when as there was no trace of the complaint remaining, she was pronounced to be cured, and I believe has never had any relapse.

The following case, attesting the value of electricity in facial paralysis, I gladly insert, because it comes from a source which cannot be questioned, and is valuable on account of the precise and accurate observations. It is a case of facial paralysis brought on by sudden fright.

W. A. G., æt. 9, a stout, yet delicate girl, has never had any illness except measles and weak eyes. On the 15th October last, two months ago, she was frightened by a drunken man falling down in her father's shop. About two hours afterwards her mother came home, and observed that she could not close her right eye, and that the face was drawn over to the left side. She had then quite recovered from her fright, and was apparently well. Such are the particulars given by the mother.

The treatment consisted of ferruginous tonics and alteratives. On the 7th December the face was galvanized, and after a week, there being no improvement, sparks were taken instead.

From this time she quickly improved, and in a fortnight was able to close the affected eye completely.

She was perfectly well at the end of three weeks.*

The following is a case of paralysis of the face, as well as of several other parts of the body.

In 1852 W. L. applied to me paralyzed down his right side and in the face, which was much distorted—the saliva flowing freely from the right corner of his mouth. He attributed this attack to exposure to wet and cold, while under the influence of mercury. The affected parts were subjected for some time to electro-galvanic currents. The face, hand, and arm perfectly recovered, and the leg so far that he was able to walk several miles at a time.[*] I found it impossible completely to restore the leg.

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* Guy's Hospital Reports.

In the same year, Sir R— applied under the following circumstances: He had been at Madame Tussaud's one evening; the rooms were very much crowded, and the air close and excessively hot. When he left the rooms he was very much heated, and was perspiring freely. In this condition he went out into the open air, and caught cold, which resulted in paralysis of the face, arm, leg, and loss of voice, accompanied by great difficulty in swallowing. When he came to me, the saliva was flowing profusely from his mouth; he had been under medical treatment, and mercury had been given to induce salivation.

I applied the electro-galvanic current to the throat and face, and after three or four applications, there was a decided amendment. After twelve applications all the symptoms had disappeared, and the patient was perfectly restored.

The cases of facial palsy above described are quite sufficient to prove the valuable powers of the electro-galvanic current in the treatment and cure of facial palsies; and this too where other means had completely failed. Indeed, from the wonderful effects of galvanism mentioned in some of the foregoing pages, in which it appeared that it forced even the dead body to simulate the living, we might naturally infer that galvanism would be found to exert astonishing power over the nervous system. I shall conclude the subject of facial paralysis with the following case from my work on "Electro-magnetism," referring to it for further information.

C. N., a printer, 20 years of age, walked home in February 1841, in a very cold night, with a piercing easterly wind, when greatly heated from dancing. The next morning he had an inflammatory swelling of the left cheek, accompanied by acute lancinating pain; and on the inflammation subsiding, the left side of the face remained swollen and paralyzed. His medical man employed the usual remedies without any benefit. On the 5th May 1841, the patient consulted me. The left side of the forehead and eyebrow were perfectly motionless, the left side of the nose was lengthened, and the nose was drawn to the right side. The left corner of the mouth dropped a little; on opening the mouth, the teeth on the left side could not be seen. The left side was motionless on laughing, whilst the right was drawn towards the right ear. The patient could not whistle, and on drinking, the fluid ran out at the left corner of his mouth. In this case I confined the treatment to the employment of electro-magnetism, which was daily applied for four months. The induration of the cellular tissue first began to soften in the lower half of the cheek.

After the second application of the electro-magnetic current, fluids did not run out at the corner of the mouth.

4th week. The flow of tears had ceased.

6th week. He was able to whistle, and to move the eyebrows a little.

12th week. The eye could be quite closed, and firmly compressed.

16th week. The swelling of the left side of the face had entirely disappeared, the motion of all the parts was nearly restored, and very little difference could be seen, on laughing, between the two sides of the mouth. A few more applications completely removed all traces of his former complaint.

In January, 1842, his father called on me to say that his son continued quite well.

I shall now proceed to notice the other kinds of rheumatic paralysis. Whilst facial paralysis distorts and disfigures the appearance, palsy of the limbs is even more unfortunate, as it disables the patient, rendering him helpless, and incapable of the least exertion, though possibly his means of subsistence may depend thereon. I shall not attempt to describe any of the divisions of paralysis, because such are not essential in considering rheumatic palsy; and further, as my object is to show the value of electro-galvanism, rather than to point out all the methods of cure, the adoption of any such would be quite unnecessary.

On the 10th March, 1850, R. P., a working man about forty years of age, was attacked by rheumatic paralysis, in consequence of which he totally lost the use of the right arm. He attributed this attack to going out into the rain, when perspiring, and getting wet through. He was soon after attacked with acute rheumatism, from which he suffered a good deal. On the acute symptoms subsiding, he found that he could not move his right arm, which hung quite immovable. When desired to move the arm, he made an effort, but raised the shoulder only, and by no exertion could he do more. He felt a sensation of numbness, the arm was quite cold to the touch, and if passive motion were attempted, it gave rise to intense pain.

He had been under medical treatment, and when the acute symptoms had subsided, he was left in the state just described. On the 22nd March, I applied a gentle electro-galvanic current for twenty minutes, and this was repeated daily until the 13th April, when he was perfectly well, and returned to his employment.

In 1850, G. B., aged twelve, applied, having totally lost the use of the left arm. It appeared that about ten years before he was attacked with fever; and when the fever left him, the arm was found to be paralyzed, and had continued so ever since. The limb appeared to consist only of skin and bone, and was quite incapable of grasping, holding, or of lifting anything. He was also unable to touch any object, as there was no power of directing the limb; instead of touching the object he desired, the hand would perhaps pass in an opposite direction.

I commenced the electro-galvanic treatment in the usual way. After a daily application for three months, the patient was perfectly cured; the arms were equal in strength and size—in fact, the arm which had been diseased was rather the larger of the two. He was shortly afterwards engaged to work in a needle manufactory. In 1853 he called upon me before leaving England for America, to thank me for what I had done for him; he had the free use of the arm, and was able to use it quite as well as the other.

These two cases were instances of partial paralysis, the first succeeding to acute rheumatism; from the lapse of time in the second, I could not trace it to anything more than fever, but what sort of fever no one knew.

Treatment had been adopted in both instances with but partial success. Electro-galvanism succeeded in rapidly restoring the first case to health; the second required much longer time, in consequence of the wasted state of the limb, as well as from the circumstance that the will had lost its authority for so many years; indeed, we may say, had never been exercised.

The two following cases I insert, not from their severity, but from the singularity of the cause to which the patients referred their disorder.

In 1853 Sir W— called upon me, complaining of great stiffness, pain, and difficulty in moving the shoulder. The inability of moving the limb rendered it impossible for him to get his things on without assistance. He attributed it to the kicking of his gun while out shooting. A few applications of the galvanic current restored the free use of the shoulder.

In the same year Sir J— came to me, affected in the same shoulder, and from the same cause. This patient had been electrified, but without deriving any relief whatever. I employed electro-galvanism, and outward applications to the shoulder for three weeks, when the patient was perfectly cured.

In 1851 Mrs. B., a washerwoman, applied to me, as she had lost the use of her right arm. She first felt severe pain, which ultimately terminated in a total loss of the use of that limb. She had applied blisters, and many external applications, for some time without any result. Electro-galvanism restored the use of the limb in three weeks.

In July 1852, M. A., a servant who had been living in a cold damp kitchen, the flooring of which was of stone, was sent to me by her employer suffering from severe pain and swelling of both ankles. This complaint had been gradually coming on for some time, and she had taken no notice of it until she was no longer able to move about.

I employed the electro-medical treatment, which soon afforded her relief; and at the end of a fortnight she was able to return to the country quite well. As she derived so much benefit from galvanism, she took a small galvanic apparatus with her: and on several occasions when she had pain in either of her ankles, she applied the current, and always removed it. With the exception of an occasional pain, she has been quite well, and able to attend to her duties, without any return of the complaint to the present time.

The following case of rheumatic paralysis of the leg I transcribe from the Guy's Hospital Reports, as it confirms my opinion of the benefits to be derived from electricity.

"February 14th, 1850. M. O., aged thirty-seven, a married woman occupied only in domestic service, states, that fourteen weeks ago, she was (when recovering from choleraic diarrhœa) exposed to damp and cold during menstruation. In the night she felt a numbness come over her legs, and in the morning had scarcely any sensation from the hips downwards, neither could she put one leg before the other without help.

"Ordered to be galvanised.

"March 7th. She has attended regularly, and improved astonishingly. After a few days from the date of this report, she left off attending, being able to walk with facility, and returned to the duties of her family."

The following is an instance of rheumatic paralysis affecting the half of the body, which came under my care on the 30th June, 1853.

Mrs. K., a stout person, who had always enjoyed good health, had been sitting between two open windows all the evening, and went to bed apparently quite well. The next morning she found that she had lost the use of her right side, and all sense of feeling. She was immediately placed under medical treatment; and when she came to me she was able to walk with assistance, but the arm felt numb, heavy, and very stiff. I applied the electro-galvanic current from the shoulder to the hand. In a short time she derived considerable benefit; and as she resided about ten miles from my house, she determined, in consequence of the heat and fatigue, to procure an apparatus, and to continue the application under the direction of her own medical attendant. When I last heard from her, she was progressing most favourably, and, I believe, has quite recovered the use of her arm.

It may possibly occur to some of my readers, that a large proportion of the cases here detailed are nothing more than mere muscular pains, rendering motion painful and difficult. This, however, betrays a very limited acquaintance with the nature and phenomena of rheumatic complaints. Palsy is generally looked upon as so decidedly *incurable*, that when a cure has been effected it leads rather to disputing the reality of the disease, than to the assigning of due credit to the means employed. The late Dr. Golding Bird remarks on this subject: "Under the term rheumatic paralysis, I would include all cases in which the palsy followed the sudden application of cold, independently of any evidence of central spinal lesion. Such cases are common enough; they are sometimes attended with peripheral pains of a rheumatic character, and even occasionally with redness and tumefaction of the joints, which, however, are always evanescent. The line of demarcation between rheumatism and some of these forms of eccentric paralysis is very ill-defined; and, indeed, lends considerable support to the idea of a close connection between rheumatism and some lesion of functions over which the true spinal system presides. Paralysis of the portio dura is a not unfrequent affection; and I dare say it has fallen to the lot of my auditors to be called to cases of this kind, after the patient has been bled, cupped, blistered, mercurialized, and his health and constitutional power shattered by such unnecessary treatment—a treatment for which the most profound ignorance hardly affords an excuse. The history of the case is sufficiently intelligible. A person previously in health exposes one side of the face to a little draught of air, as by sleeping near a window having a broken pane, or travelling in a railway-carriage with a half-open window. The result of this is more or less pain and stiffness in the side of the face, followed soon by paralysis of the nerve. In such cases, the stimulus of electricity remarkably aids the cure: I say the stimulus of electricity, because in such cases it appears pretty certain, that the agent in question acts merely as a local excitant, stimulating the paralysed muscular fibres, and arousing their normal irritability, and once more placing them under the dominion of the will."

CHAPTER XI.

THE PARTIAL PARALYSIS OF CHILDREN, OR PARALYSIS DURING DENTITION.

Having considered paralysis as a consequence of rheumatism, I now come to a variety which is often the cause of a great deal of alarm and uneasiness. I refer to that partial paralysis which attacks children of the most tender age, often appearing without the slightest warning, and without any obvious cause. This affection, however, if not strictly confined to, is much more frequent during dentition, than any other period of the infant life: it has also been observed to occur, either as the immediate precursor of some febrile symptoms, or during the progress of such disorders, leading us to infer that at this tender age some predisposition to the complaint exists.

When it attacks during or in connection with dentition, it generally makes its appearance as follows:—A child from six to twenty months old is put to bed in apparently perfect health, or, it may be, slightly feverish. It passes a restless night, and the next morning an inability to move the arm freely from the shoulder, or the leg from the hip, is discovered; the power of motion gradually decreases, till complete paralysis has supervened, and the muscles of the palsied limb become soft, flabby, and attenuated, giving the limb a withered appearance, sometimes attended with deformity. In some instances, complete paralysis comes on much more rapidly.

Upon the strictest examination, no trace can be discovered of the brain being in any way implicated; the stomach will be found occasionally more or less deranged, but not to an extent to enable us to unravel the mystery.

The relief, and indeed the total removal of this disease, is by no means, at least in the generality of cases, a difficult matter; but if treated by purgatives, calomel, blisters, &c., it will most assuredly become inveterate, and irremediable paralysis with withering of the limb will be the result. For not only are such means prejudicial in themselves, but by their debilitating effects they engender a cause of wasting, which probably would not otherwise supervene.

In confirmation of the value of electricity, as affording the most speedy and effectual mode of cure to which we can resort in the disease just described, I shall detail the results of a few cases treated at Guy's Hospital.*

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* Guy's Hospital Reports.

"In paralysis during dentition, electricity is often a valuable means of restoring the power of the part, and if it be neglected during the early period of the paralysis, *irrecoverable wasting* of the muscles may follow; indeed it will sometimes follow in spite of every care; but such a result is not frequent when precaution has been taken to keep up the nutrition of the muscles by the due excitement of their functions. If this is necessary in the various forms of paralysis in adults, it is still more so in children, whose active yet delicate nutrition so rapidly suffers under depression. In all infantile diseases, this truth meets us at every step, that their tissues are not only active, but growing, and hence any arrest of function is doubly injurious."

Electricity has proved so useful and so certain a remedy in this kind of paralysis, that I feel fully warranted in most strongly impressing its value upon the attention of the practitioner; and this the more forcibly, because I am perfectly aware he will have many objections to contend with, and many prejudices to surmount. "The use of electricity at this age is occasionally beset with difficulty, from the fear and general nervous excitement it occasions. This may be greatly obviated by a few simple precautions, as by telling the nurse to sit upon the insulating stool, with the infant in her arms, and by drawing the sparks through its flannel dress, rather than from the naked skin; and if galvanism be the more advisable, to use the same precautions, to avoid exciting the fears of the child, and to apply the current by means of the hand."

I shall now relate a few cases, to prove the benefit that may be derived from the application of electricity.

Paralysis of the right arm during dentition.—October 1851. A. C., æt. twelve months, a delicate child with light hair and blue eyes, was in good health six weeks ago, and had then cut six teeth. For a week preceding the present attack, had been feverish and ailing with diarrhœa, but went to bed without anything specially observable in his symptoms. During the early part of the night he was restless, and the next morning his mother observed, on washing him, that he was unable to raise the right arm, which fell loosely by his side, the muscles of the shoulder being quite relaxed. The paralysis has continued, and the muscles have wasted; he is able to move the fingers, though not in any degree to raise the arm. There is no sign of irritation about the gums. Jan. 29th. Much improved, can raise his hand to his mouth—electricity continued. February. Still further improvement, can move the arm and hand in any direction. There remains slight feebleness in the action of the flexor muscles of the fore-arm.

Paralysis of the left leg.—March 18th, 1851. W. L., aged ten months. Paralysis of the left leg came on rather suddenly, without attracting much notice, when she was only six months old. The symptoms were those usually observed in such cases.

April 6th. This child has been regularly electrified, and is greatly improved. She can now take three or four steps alone, which she has not done before.

22nd. Her mother now ceased to bring her. She is quite recovered, and runs about freely.

Paralytic weakness of the arms.—March 8th, 1850. A. B., aged five months, a well-grown, healthy-looking child, recently recovered from a secondary eruption. The mother states, that about a month ago she noticed that the child had lost the power of lifting up its arms, the right seeming to be the weaker. She has, however, sufficient power to grasp anything in her hand. These symptoms had not been preceded by, nor attended with anything like a fit, nor with any spinal or cerebral irritation. This child was regularly electrified, and on the 17th April had completely recovered.

Paralytic affection of the left leg during dentition.—April 18th, 1848. F. W. H., when only ten months old, during the cutting of the first teeth, lost flesh, and was much reduced. The mother observed about this time, that the left leg was weaker and smaller than the right. The general health was good, and has been so, although he was weaned when only two months old, in consequence of his mother having suffered from an attack of acute rheumatism. The child never had any distinct fit, and appears to give evidence of having been well fed and well nourished, if we except the wasting of the left leg, the muscles of which are loose, flabby, and wasted. He can, however, move it in every direction, but cannot stand upon it.

This case was subjected to electricity, and on the 15th of May could stand without assistance.

CHAPTER XII.

GOUT.

Having considered the different forms and varieties of rheumatism, and their effects upon the human body, we come to another important affection closely allied to acute rheumatism, viz., *gout;* which is a very common disease, more especially in the higher ranks of life, though it now prevails among the middle and lower classes much more than formerly, in consequence, perhaps, of the increasing use of malt liquors and inferior wines.

Gout, like rheumatism, is divided into *acute* and *chronic*, and its seat may be either external or internal. It differs from rheumatism in not being a disease of youth: "ea raro castratos, vel pueros ante fœminæ coitum, vel mulieres, nisi quibus menstrua suppressa sunt, tentant." *

Although considered an hereditary affection, it is easily brought on by indulgence in those habits which are well known to predispose to its attacks, and the former exemption of the middle and lower classes from this complaint, contrasted with their present liability to it, may be cited in confirmation.

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* Celsus, lib. iv.

Exposure to cold is a fruitful source of gout; hence we find it prevail largely amongst coachmen, who are exposed for many hours to the cold damp air of night, and who also indulge to a great extent in malt liquors.

Over-repletion also performs a very active part in generating a gouty diathesis; and, of course, when hereditary predisposition exists, the operation of these causes will, without fail, call it into action. Hereditary gout does not always descend from father to son; for it often happens that it spares one or two generations, to attack the grandson or great-grandson; and in some cases it has been seen to attack the different members of a family uniformly at a particular age, and at the same time of the year, no matter what the season or the weather.

There are very few cases in which the disease does not recur, after having once made its appearance. Between the first and second attacks, there is usually an interval of from three to four, or even five years; but when the complaint has once gained ground upon the constitution of the patient, these intervals become shorter, until at length, in inveterate cases, two, three, or more attacks may occur within the year—the sufferer hardly enjoying any respite, except during the warm summer months.

Acute Gout.—Derangement of the digestive organs, slight febrile symptoms, heat of skin with dryness, thirst, constipation, and restlessness at night, generally precede an attack of gout. It comes on in the night, often after a fit of shivering, and is confined to one joint, generally the ball of the great toe, in which there is a sensation of great heat, accompanied by very violent grinding pain; and as this augments, there is an increase of temperature all over the surface of the body. The patient tosses restlessly in his bed, with the vain hope of relief from a change of position; the inflamed joint is exquisitely tender, he shrinks from the slightest touch, and can scarcely bear the weight of the bed-clothes upon the affected joint. After the lapse of about four-and-twenty hours, there is, in some cases, a sudden and total cessation of pain; but it is much more usual for it to remit gradually in violence, until a gentle perspiration breaks out, and the patient falls asleep. On awaking, the joint which has been the subject of the attack will be found marked with a tense shining redness, whilst the surrounding veins are turgid and distended. There is a recurrence of the same symptoms for several days and nights in succession, but each time in a milder form, and the attack terminates; the œdematous swelling and redness gradually subside, and desquamation of the cuticle takes place, attended with intolerable itching. The joint is sometimes left perfectly free from disease, though, in other cases, it becomes the seat of gout in its chronic form.

During an attack of gout there is loss of appetite, nausea, and occasionally vomiting; the evacuations from the bowels are very unnatural, being sometimes pale, dark green, or perfectly black, and very offensive.

In all acute attacks, the urine is at first scanty, high-coloured, and on cooling deposits a sediment. It has an acid reaction, is of high specific gravity, clear, transparent, and of a bright colour, resembling copper. If perfectly cloudless, and allowed to stand for some time in a glass vessel, the sides will be thickly studded with crystals of a reddish colour, and at the bottom there will be a layer of apparently red sand, gritty, and when collected and dried, appearing of a rusty or brownish-red colour. If a very minute quantity of this sand be viewed through a microscope, it will be found to consist chiefly of rhombic crystals of lithic acid.

This sediment, when it exists to any extent, precipitates from acid urine, whether warm or cold, but the lateritious sediment separates only on cooling. It may be at once recognised by heating a little of it, diffused through some of the urine, in a test tube over a spirit lamp; the cloudy urine immediately becomes transparent, owing to solution of the precipitate. The deposit, in this instance, consists of alkaline lithates, more especially the *lithate of ammonia.*

In gout, lithate of soda is the predominant salt, of which the "chalk stones," as they are named, so often deposited in the joints, almost entirely consist. The urine sometimes so abounds in the lithate of soda, that it has almost a plastic consistence, and Dr. Prout says that he has seen it copiously secreted of the consistence of mortar, so as to block up the urethra in its passage outwards.

The Diagnosis of Gout.—Rheumatism is the only disease with which gout can be confounded; and the resemblance is occasionally so close, that they may be considered as modifications of the same disease; but the treatment of each is peculiar to itself, and cannot be employed indiscriminately to either one or the other. The *diagnosis* of gout is a subject of some interest, as on its correctness in distinguishing rheumatic fever from gouty inflammation, the success of our treatment will entirely depend. In rheumatic fever, the local affection is different from what it is in gout. In the latter, the skin is more affected; it presents a deep dusky mahogany colour, shining, with the veins much enlarged; desquamation after a little while comes on, showing that the skin is diseased. In gout, there is also more œdema and effusion about the joint than in rheumatism; the swelling in one is tense and elastic, and pits on pressure, in the other it does not. The hand in gout is like a boxing-glove, more than anything else. There is less sweating in rheumatic fever than in gout; the fever of the latter is more of a remittent character, that of rheumatism is of the continued kind. Gout seldom attacks men of the age of 27 or 30; rheumatism is very common at this age. The disposition to gout is inherited, while rheumatism does not show any marked peculiarity in this way.

The parts liable to these diseases afford some distinctive characters. Gout generally selects the smaller joints, rheumatism the larger.

It may be right, perhaps, to notice here, that Dr. Garrod has examined the conditions of the blood in both gout and rheumatism; and he has found this fluid so constantly surcharged with uric acid in gout, while it is in no abnormal quantity in rheumatism, that he looks upon this circumstance as diagnostic of the two diseases. The results of his inquiries are:—

1. That in all cases of acute gout, that is, in all patients where the great toe is specially affected, and where the other symptoms are such as to leave no possible doubt as to the diagnosis, uric acid exists in the blood in abnormal quantities.

2. That in all cases of acute rheumatism, where the symptoms are characteristically marked, with or without heart affection, no abnormal amount of uric acid is present.

3. That in all acute or chronic forms of the same diseases, even when not so characteristically marked at the time of the examination, where the maladies can be distinctly traced to true gout or rheumatism, the same difference exists in the composition of the blood.

4.. That the effused fluid, such as the serum obtained from a blister applied to a non-inflamed part, contains uric acid when the blood is abnormally loaded with this body.

It has been proposed to make these facts subservient to the diagnosis of the two disorders. If, for instance, it should be a question whether a disease were really gout or rheumatism, a chemical examination of the blood would, it has been asserted, clear up all doubt upon the case. If the blood is found to abound in uric acid, the disease must be gout; but if this principle exists only in the normal quantity, we may safely treat such a case as one of rheumatism. It is not supposed for a moment that the uric acid in the blood forms the "*materies morbi*," or that it constitutes the essential principle of the gouty diathesis. It is to be regarded only as an invariable coincident, and as such, affording a certain means of diagnosis.

Pathology of Gout.—"The opinion" (says Cullen) "which has generally prevailed, is, that gout depends upon a certain morbific matter, always present in the body; and that this matter, by certain causes thrown upon the joints or other parts, produces the several phenomena of the disease."

"I am satisfied" (says Dr. Watson*) "that the ancient doctrine, which asserts the humoral origin of the disease, is the true one. 'Morbific matter (it may well be called a *poison*) is generated, or detained, under certain circumstances, within the body, and silently collects in the blood; until, after obscure threats, perhaps, and prelusive mutterings, it explodes in the foot; and then the bodily economy, like the atmosphere after a thunderstorm, is, for a while, unusually pure and tranquil. To some such conclusion as this, the result of all modern research seems clearly and unfailingly to tend." I shall take leave to refer to some of Dr. Budd's positions.

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* Watson on the Principles and Practice of Physic.

"I need not remind you of the various ways in which extraneous matters find entrance into the blood. Poisons, under their proper shape and name—medicines, which misapplied become poisons—our natural food and drink, which the folly of man converts into poison—the products or dregs of the secondary assimilative process—these are common sources of impurities, more or less hurtful, which mix and circulate with the vital fluid. Some of these extraneous matters escape harmlessly by one or more of the waste-pipes and emunctories of the body. Some are entangled in its solids, but not indiscriminately, for different substances have their special or their favourite resting-places. All this is well known to persons conversant with toxicological researches."

Now this doctrine of the elective affinity between certain tissues or parts of the body, and certain morbific principles conveyed to them by the blood, is applied by Dr. Budd to elucidate the very curious fact of the symmetrical local manifestations of many disorders, which disorders are themselves so far general, that they derive their origin from the circulating fluids. This symmetry he finds the most exact in chronic constitutional complaints, wherein the local morbid changes are effected in a manner which approximates closely to the processes of healthy nutrition. He shows good reason for believing (what, if the whole theory be true, we should expect) that the same symmetrical phenomena are modified by the *amount* of the poison collected in the system. If there be a certain quantity only, it may settle in some favourite or congenial spot, on one side of the body. If there be more than enough to saturate that part, it goes next to the corresponding spot upon the opposite side, or, perhaps, to an analogous part of the other limb of the same side. If there be more still of the poisonous material, it flies to, and occupies other parts also. He further shows that the elective affinity is more exclusive, and the bond of union stronger, in respect to some morbid principles than to others; and in proportion as the affinity is weak, so is the local manifestation of the disease apt to shift, by metastasis, from place to place. When the matter which has thus entered, or combined with, a certain tissue or organ is anyhow loosened and released from that union, or repelled from the part, it is again set afloat in the blood, to "break out" elsewhere; to tease various organs, perhaps, or to derange the whole economy. The alternation so often to be noticed between certain cutaneous eruptions and internal disorders of function, is a striking and familiar example of this. The eruption afforded presumptive evidence of the detention of some peculiar morbid principle in that part; and the internal affection which succeeds the disappearance of the eruption, denotes that the morbid principle has re-entered the blood. Some of these peccant or poisonous matters fix permanently in the affected spot or spots; and some of them may even be recovered in substance from the dead tissue by chemical means; the poison of lead, for example, from the symmetrically palsied muscles. Others appear to be expended gradually in the part, and so are eliminated from the system.

Dr. Budd observes, that the regular arrangement of these local tokens, whether they be outward or internal, is disturbed by the presence of fever. Probably the febrile tumult may itself be owing to the quantity of the noxious matter in circulation within the body. He states also, that, *cæteris paribus*, this morbific matter is most apt to pounce, in the first instance, upon parts which have been previously hurt, or which are mechanically irritated at the time. For which reason, a part that has once been affected by it, is more likely than other parts to suffer again.

Now, see how thoroughly the ascertained phenomena of gout accord with this theory. Certain habits of life produce fulness, and richness and impurity of blood—the same habits which breed the lithic acid diathesis. We may even conjecture this acid, or some of its compounds, to be the actual *materies morbi.* Lithates are poured forth with the urine, and sometimes deposited in vast masses around and within the gouty joints. At first, after obscure intimations of the presence of the poison in the system, it thunders in the foot, and there, perhaps, is all discharged and spent. The chemist Berthollet found that the skin of a part affected with gouty inflammation communicated instantly to litmus paper a deep red colour: a large quantity of acid was evidently passing off by exhalation from the inflamed surface. If the poison be too copious to find sufficient vent in one joint, it attacks another, or more than one. A chain of repeated paroxysms at length purifies the blood: "donec tandem materiâ peccante prorsus absumtâ, æger pristinam obtinuerit sanitatem."*

The fact so clearly established by Dr. Garrod, of the large amount of uric acid existing in the blood of gouty patients, has attracted much attention; for the presence of so large a quantity of this acid in the blood shows that it is in some way intimately connected with the gouty diathesis.

Uric acid is a purely animal acid, and like all organised products, consists essentially of four simple elements, viz., carbon, hydrogen, nitrogen, and oxygen. Uric acid is a noxious principle, evolved during the operations of the living system, and in a state of health eliminated and ejected through the kidneys. It is a principle in the phenomena of life, that every part of the frame should waste, become effete, and be evacuated, while it is replaced by new material. Excretion and assimilation are the terms by which these processes have been denoted. The production of uric acid in the system is the result of the former, and arises from the decomposition and metamorphosis of the albuminous and gelatinous tissues.

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* Thom. Sydenham, tractatus de podagra et Hydrope. Lond. 1683.

Liebig, who has entered at great length upon all these matters, considers that it is oxygen that causes the changes which take place in these albuminous substances, and that it occurs only when the chemical force is sufficient to overpower the resistance which the vital force can oppose to it.

The oxygen of the atmosphere is the operating cause of the waste in the body, and it is always tending either to disturb or entirely to suspend the vital forces. The resistance which these make depend upon a variety of circumstances, such as age, habit, strength, &c. When the vital forces are no longer capable of offering the necessary resistance, death ensues; oxygen combines with the elements of the tissues, according to those laws of chemical affinity, by which the force of their mutual attractions have been determined. These laws are the cause of the decomposition which dead animal or organic matter is observed—at least if left to its own operations—invariably to undergo.

But the gelatinous tissues in like manner undergo change, and this is also attended with the production of *uric acid.* According to Liebig, this can take place only at their surface, and the same rule will apply to almost all the membranous tissues which receive but a small proportion of oxygen ; consequently, the changes in these go on more slowly than in the more vascular tissues, in which the supply is more abundant. Now we find that the deposition of urate of soda takes place chiefly in the cellular tissue about the joints, in the cartilages of the joints, and occasionally, as before observed, in the skin itself, and the external appendages of the ear. Sometimes it appears as a powdery matter thrown out upon the surface of the skin.

Uric acid is a very insoluble acid—that is, in its pure or uncombined state—requiring, according to Prout, nearly ten thousand times its weight of water for solution, while Liebig asserts that it requires fifteen thousand times that quantity. But although so insoluble in its free state, it is rendered much more soluble by combination with alkalies—ammonia or potass, for example—and it is by uniting with ammonia that it is held in solution by the urine, and so evacuated from the system.

Nor is this the only means by which its ejection from the system is effected. Uric acid readily undergoes transformation. Oxygen converts it into principles of greater solubility. But if from any cause—long-continued excess, insufficient exercise, or other irregularities, there should be a deficiency of oxygen—then the urate of soda remains and appears as a deposit.

The kidneys seem to be the outlet to which nature invariably resorts for the evacuation of uric acid. The urine is very seldom found wholly destitute of this principle, except in the case of disease. Of this any one may satisfy himself by adding a few drops of acetic or hydrochloric acid to urine and allowing it to stand. After a time, the test-tube in which it has been allowed to remain will be found coated on its interior with crystals of the acid.

The urine is found to contain another principle—*urea.* In gout this principle, as well as the uric acid, abounds in the urine. If for instance the urine of a gouty patient be placed in a watch-glass, and nearly its bulk of nitric acid be added, it will often become a solid crystalline mass ; the time required for which, being in some degree, proportioned to the quantity of urea in solution. This solidification is owing to the combination of the acid with the urea, giving rise to the formation of nitrate of urea, a rather insoluble salt.

The urine affords us the most effectual as well as the most trustworthy means of forming rational conclusions upon such points. If the tissues undergo rapid changes, whether these result from a superabundant supply of oxygen, or any other cause ; and if the oxygen be in sufficient quantity to allow of the transformation of the uric acid into urea and carbonic acid, or the other principles into which it is convertible, there will be no deposit in the urine, notwithstanding the large amount of uric acid generated. If, on the contrary, the tissues do not undergo transformation, then there will be no uric-acid deposit, because no uric acid has been formed for either transformation or deposition, and consequently none will either separate spontaneously, or be precipitated from the urine. If, however, uric acid be formed, but that from deficiency of oxygen, or from some other cause, its transformation should not be effected, then it will abound in the body, and will be found separating even spontaneously in great quantity from the urine, as so often observed in gout; and this shows the importance of frequently examining the conditions of this secretion in all cases in which the gouty diathesis prevails.

The above facts have induced Dr. B. Jones to lay down the following laws: that the quantity of uric acid thrown out varies inversely with the amount of action of the oxygen; and thus the problem of the cure of the uric-acid diathesis depends, tonics being excepted, on the question—how the uric acid in the body can be most acted on by oxygen, how it can be changed into urea and carbonic acid? "It appears," says this author, "that this may be done—

"1. By giving a large supply of oxygen; as by exercise, by cold air, and by medicine, as by nitrous oxide, water, and iron.

"2. By diminishing the quantity of other substances, on which the oxygen acts more readily than on the uric acid; that is, substances consisting of hydrogen carbon, and oxygen only; as by abstaining from these as food, by removing them by aperients, and by sudorifics.

"3. By keeping all the uric acid, which is produced, in solution by water and by alkalies."

From what has been stated, we arrive at this fact, viz., that the inflammation in gout and rheumatism is of a specific character. That there is a considerable analogy, though a marked distinction, between the two diseases. In rheumatism, the blood contains barely the normal quantity of uric acid; in gout, the blood is largely surcharged with this principle. Its presence in abnormal quantity has been attested by the examination of 200 cases of gout, and consequently there can be but little doubt as to the general rule.

But notwithstanding all these researches, we still feel ourselves in this dilemma—that we are unable to form any rational notion of the immediate cause of gout or rheumatism. They are unquestionably inflammatory disorders, but these inflammations differ very much from the ordinary forms. That the inflammation derives its specific character from some peculiar diathesis, seems certain, causing the generation of uric acid in exceedingly large quantity, and that while a great deal of it is expelled with the urine, a large quantity is retained in the blood, and circulates through the system. During this transmission, the uric acid meets and combines with soda, forming those gouty concretions commonly called "*chalk-stones,*" which are deposited in certain of the tissues, but more particularly in those about the smaller joints.

Treatment of Acute Gout.—Gout, as already stated, is in many instances an inheritance, and the predisposition to it may be regarded as an integrant of constitutional formation, not to be easily eradicated. Again, when this disposition has been acquired, it is the result of a lengthened perseverance in errors and irregularities, and in proportion resists all attempts at being expelled from the system. So long as the remote causes remain in active operation, we may relieve for a time, or ease pain, but most assuredly the symptoms will return with all their original, if not with increased violence.

It has been observed that luxurious living, excesses of various kinds, an indulgence in malt liquors and poor acescent wines, are powerful excitants of gout. The first thing to be done is to arrest the operation of the remote causes. Regimen, therefore, will properly attract the first attention of the physician. He will restrict not only the quantity and quality of the ingesta, but also every provocative to excess. And first "condita omnia duabus de causis inutilia sunt; quoniam et plus propter dulcedinem assumitur, et quod modo par est, tamen ægrius concoquitur." *

To render moderation more easily borne, and by far less irksome, simplicity in the food forms an essential in the system: "At si neque vis, neque cupiditas deest," says Celsus, "nulla varietate solicitandus æger est; ne plus assumat quam concoquat." * And the same authority tells us that a variety in food does not render it more easy of digestion, as asserted by some, for he continues: "Eduntur quidem facilius: ad concoctionem autem materiæ genus et modus pertinent."

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* Celsus, lib. i., cap. vii.

A due performance of the different functions is absolutely necessary to health: nutrition to repair the waste, secretion to deposit or separate, as the case may be, what is required, and excretion to evacuate the effete principles from the body, which, if retained, would act as poisons. The treatment of gout, indeed, we are told, is very simple, embracing only "flannel and patience." That the first attacks of gout will abate under such management cannot be denied; but those who wholly trust to such means will have cause to lament their confidence, for lithate of soda will be deposited in the joints, which will increase the irritation and the tendency to return, while the future severity of the attacks will be greatly aggravated.

Gout, especially in the acute form, presents all the phenomena of inflammation. General or local blood-letting, as well as active antiphlogistic remedies, are contra-indicated. The bowels should be evacuated by warm aperients, combining them with such medicines as act upon the skin, liver, and kidneys.

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* Op. cit., lib. iii., cap. vi.

But the grand remedy—the specific, as it were, for gout, is *colchicum*. This drug has certainly the property of easing the pain in an almost magical manner. There are several preparations of this medicine in use—the wine of the bulb, the wine of the seeds, the vinegar of colchicum, the acetous extract made by evaporating the vinegar, and the inspissated juice of the plant itself. These are, all of them, active and valuable medicines.

The mode of administering the remedy is the following. You may give it in a saline draught at bed-time, and again in the morning in a warm black dose—repeating this sequence if the gout continue. In some cases the pain is calmed and the swelling reduced in a few days—in others, as if by a charm, in a few hours.

Dr. Paris states that he finds blue pill and extract of colchicum mutually to assist the action of each other.

As the alkalies, especially the bicarbonate of potass, are very excellent remedies in gout, some difference of opinion exists as to the propriety of giving them and the colchicum together, it being asserted that the alkalies, by neutralizing the acid which renders the colchicia soluble, and setting this free, render it less active. Dr. Scudamore, however, used to give *magnesia* with colchicum, and when the objection was made to him, that such a combination was *chemically* incorrect, he replied, "With the chemical incompatibility I do not trouble myself; I feel perfectly confident of its curative powers, and with that I am satisfied."

When the stomach is debilitated, and suffers from the refrigerating effects of salines, the colchicum may be given in camphor-mixture, or in some aromatic vehicle, as cinnamon, or peppermint-water. As an auxiliary, from half-a-drachm to a drachm of the sweet spirits of nitre, with a drachm of the compound spirits of juniper, may be added; or the colchicum and sweet spirits of nitre may be given in the infusion of juniper, which, although not officinal, may be readily prepared. By these means we shall set the skin, the liver, and the kidneys to work—the three grand outlets through which the noxious principles which deteriorate the blood are eliminated from the system. Dr. Bird* observes, "As a general rule, whenever the functions of the skin are impaired, where a due amount of secretion is not exhaled from the surface, an excess of nitrogen is retained in the blood, and ultimately separated by the kidney in the form of urate of ammonia, or perhaps urea, or creatinine, which substances contain respectively 38, 46, and 37 per cent. of this element. A person in apparently good health experiences from exposure to a current of cold air a slight check to perspiration, and the next time he empties his bladder, he voids urine of a deeper colour than is usual with him, and on cooling, it becomes turbid, from the precipitation of urate of ammonia. The explanation of this phenomenon, with which every one is familiar, is found in the kidneys assuming temporarily a kind of compensating function for the skin. It is true that uric acid, or urate of ammonia, is not naturally expelled from the surface of the body; but certain organic matters, rich in nitrogen, certainly are; and if their proper emunctory, the skin, has for a time its function arrested, they are probably filtered from the circulating mass by the kidneys, in the form of urate of ammonia. That nitrogenised products are exhaled from the skin, is indubitable. Dr. Faraday calcined pure river sand, and on heating it with hydrate of potass, it yielded no trace of ammonia. On merely passing this sand over his hand, and then treating it in a similar manner, ammonia was evolved. A piece of ignited asbestos, by mere pressure for a short time between the fingers, absorbed enough of some nitrogenised organic matter to evolve ammonia when heated with hydrated potass.

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* Urinary Deposits.

"I have two or three times been consulted in the cases of patients lying bedridden from rheumatic gout. One or both legs being covered with an eczematous eruption, and the parts on which the exudation had dried, have been actually frosted with microscopic crystals of urate of soda.

"Although my observations have not been sufficiently extended to warrant its announcement as a general law, I may state that in cases of lepra, psoriasis, and icthyosis, where the excreting functions of the skin have been much impaired, the urine has been much richer in urea than was consistent with health."

It is quite certain that the value and importance of the functions of the perspiratory system, in relation to the rest of the organs, have not been sufficiently estimated. The following observations of Mr. Erasmus Wilson* on this subject are exceedingly striking and interesting:—"I counted the perspiratory pores in the palm of the hand, and found 3,528 in a square inch. Now each of these pores being the aperture of a little tube of about a quarter of an inch long, it follows that in a square inch of skin on the palm of the hand, there exists a length of tube equal to 882 inches, or 73·5 feet. Surely such an amount of *drainage* as 73 feet in every square inch of skin, assuming this to be the average of the whole body, is something wonderful, and the thought naturally intrudes itself—what if this *drainage* were obstructed?" "The number of square inches of surface in a man of ordinary height and bulk, is about 2,500; the number of pores, therefore, is 700,000, and the number of inches of perspiratory tube 1,750,000; that is, 145,833 feet, or 48,600 yards, or nearly 28 miles.

"From a series of careful observations, Seguin † ascertained that, on an average, eleven grains of matter were exhaled from the skin in a minute, equal to 15,840 grains, or 33 ounces, in 24 hours. Consequently, the amount of perspired matter very nearly equals that of the urine. The exhaled fluid was afterwards examined by Anselmino,* who found that it contained, on an average, 0·88 per cent. of solids; and 100 grains of this solid extract contained 22·9 grains of saline matter. Hence in the course of 24 hours the skin exhales—

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* Practical Treatise on the Human Skin.

† Mémoires de l'Académie des Sciences.

Organic matter	107·47	grains.
Saline matter	81·92	„
Water and volatile matter	15,650·61	„
	15,840·00	„

This organic matter contains much nitrogen, and I have more than once detected in it a body resembling, if not identical with, urea—an observation confirmed by the researches of Landerer.

"Berzelius† states that osmazome, another nitrogenized substance, is an ingredient in the perspired fluid. It may be safely assumed, that when the skin is unable to perform its functions, the 107·47 grains of organic matter, which then lose their proper outlet, appear wholly or partly in the urine in the state of urate of ammonia."

The local treatment consists in keeping the inflamed part wrapped up in medicated cotton-wool and oil-silk, which excites perspiration, and is generally attended with the most beneficial effects.

Unless there is an unusual amount of inflammation, all cases of gout, especially those which occur in persons of enfeebled constitution, where the swelling is considerable and of an œdematous character, but not very red, will derive the greatest relief from the following application:—

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* Tiedemann's Zeitschrift, B. iii.

† Traité de Chimie. Paris, 1833; T. vii.

Opobalsam: ver: ʒvj.
Cinchonæ rubræ, ʒj.
Croci, ʒiv.
Salviæ
Sarzæ, āā ℥j.
Spirit: rectific: lbij.

One part of this mixture to be mixed with two parts of lime-water. Two ounces of the preparation are then to be poured upon a linseed-meal poultice, large enough to cover the whole of the affected part. The poultice must be secured by means of flannel bandages, and allowed to remain on for 24 hours, by which time the pain will have ceased, the part will feel easy, and the patient able to sleep. On removing the poultice, a peculiar and very disagreeable smell will arise from the part.

The treatment of a gouty patient during the intervals of his attacks of gout must be principally directed to his mode of living, and he must abstain from rich diet, wine, and malt liquors. He must take plenty of exercise, and none is so good as that of walking, but it must never be *violent*, as it may, by straining any part, or by causing great fatigue, excite a paroxysm. Early and regular *hours* are very necessary, and the avoidance of *exhausting mental* application.

In the commencement of this disease the patient may, by attending to this regimen, be rewarded by complete immunity from any return, or the attacks may be feeble, few, and far between. It is difficult, however, to prevail upon patients to forego their accustomed indulgences, and they desire that some medicine may be found which will avert the disease, without their being compelled to exercise any self-denial. "To gratify this desire" (says Cullen) "physicians have proposed, and to take advantage of it empirics have feigned, many remedies."

One of these was the famous Portland powder, of which Heberden remarks: "Unum est ex multis quæ vocantur remediis specificis, quorum ortum, et splendorem, et occasum vidi." It consisted chiefly of bitters and aromatics, and had descended, with some slight variations in its composition, from the time of Galen A.D. 170. Sir Henry Halford recommends a better form of prophylactic remedy, viz., a few grains of rhubarb, with double the quantity of magnesia, every day; or some light bitter infusion, with tincture of rhubarb, and about fifteen grains of the bicarbonate of potass.*

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* Dr. Watson's Lectures.

CHAPTER XIII.

CHRONIC GOUT.

It has been stated in the last chapter that the fits of gout diminish in severity, and the symptoms assume a milder form in proportion to the frequency of the attacks. It has also been observed that the smaller joints are more liable to be affected than the larger ones; yet the knee, the ankle, the elbow, and wrist by no means enjoy perfect immunity, and it is when these are primarily attacked that the disease is so often mistaken for rheumatism. I could cite several instances of such errors of diagnosis, errors of the greater moment, since we cannot treat even acute gout with the same activity as we could rheumatism.

As, however, the disease assumes the chronic character, the smaller joints, which up to this period may have remained healthy, will certainly become implicated; and this, especially should one of the joints of the great toe swell and be red and painful, will at once determine the *gouty character* of the complaint.

The fingers suffer in a similar way, the pain felt in them is incessant, it undergoes exacerbations and remissions, but does not entirely cease till a considerable time has elapsed, and will even then break out again after a short interval. As a consequence the finger joints become permanently enlarged, and this swelling causes deformity and weakness, so that the patient has but little use of his hands, and can neither grasp or hold anything firmly; indeed in some instances the fingers are so powerless, that he is quite incapable of assisting himself. When the larger joints have been repeatedly attacked, they too become distorted and sometimes even completely anchylosed. Another result, and one which gives rise not only to great inconvenience but also to considerable disfiguration, is the formation and deposition of what have been misnamed "chalk stones." I say misnamed, because there is no analogy whatever between these gouty depositions and chalk. Chalk consists of carbonic acid and lime, whereas the gouty concretion is composed of *lithic acid* and *soda*, and is therefore a *lithate* of *soda*. These formations take place and are deposited in all the joints of the fingers: thus I have seen persons who had small knotty enlargements of the joints of every finger on each hand. The secretion takes place at first in a plastic form; I have seen instances where I could perceive this plastic matter oozing out of small apertures which it had made in the neighbourhood of the joint; and I remember one patient, a man who used to bring a quantity of this chalky matter in a plastic state upon the plain surface of the foot of a wine-glass.

Nor are these depositions confined to the joints; although these are their most frequent seat—they sometimes form on the ears, about the nails, and in the follicles of the skin. It is said that some patients can write on a slate with the chalk in their knuckles.

It has been observed that when gout becomes chronic it is more permanent but less painful. This, however, is not always the case, for in some of its inveterate forms it proves a terrible disease; and the pain is so excruciating as to defy the fortitude of the helpless sufferer. In the milder but more insidious forms it proceeds slowly but surely; impairing the natural strength and vigour, producing languor and inactivity, till at last it undermines the constitution and completely breaks up the health.

Treatment of Chronic Gout.—The treatment of this form of gout must be conducted nearly on the same principles as that of the acute, but a greater perseverance in the application of them will be necessary. Galvanism will prove a most useful addition to the usual course of medical treatment; and from this combination of means we may hope for results which too frequently are looked for in vain from the use of medicine alone, however judiciously it may be administered. Abundant evidence exists of the efficacy of galvanism as a therapeutic in chronic gout; and in confirmation I shall briefly detail a few cases which have come under my own observation.

Mr. C. was attacked in 1850 with rheumatism, which after some time assumed all the characters of rheumatic gout. The disease first appeared in the hands, knees, and ankles. These swelled, became very painful, and the symptoms at first were very acute. After a little while the disease assumed the chronic character, and the smaller joints, as the fingers, became implicated. The patient soon became helpless, was unable to walk or to use his hands.

The patient had been for several months under medical treatment. On application to me I prescribed the treatment before stated, and applied galvanic currents to the affected joints. The medico-galvanic treatment was pursued with short intermissions for three months, at the end of which time he was able to return to his counting-house and to resume his duties, which he had been compelled to discontinue. He was able to walk there, a distance of four miles, and back. I hear of him occasionally: up to the present time he has remained quite well, and has not had another attack.

Mrs. F., æt. 28, was attacked with rheumatic fever, the left wrist being first affected with swelling and severe pain. The skin was very red, and every attempt at motion caused excessive pain. On the second day the left knee became painful, and this was attended with the usual symptoms. The disease gradually but slowly yielded to medical treatment, but the knee continued to be stiff and painful, and the pain was much increased on any attempt to move the joint.

The knee was kept warm and perfectly motionless for several weeks, at the end of which period no change having taken place she came under my care.

I adopted the medico-galvanic treatment, under which she gradually improved, the pain and swelling subsided, and at the end of three weeks she declared herself perfectly well. The treatment was continued a short time longer, when all trace of her complaint had disappeared, and she has had no return of the disease.

Mrs. M., æt. 40, had been for several years suffering from clearly-marked rheumatic gout in the right hand; the wrist and fingers of which were very much swollen, the joints of the fingers being enlarged and distorted, arising from a deposit of " chalk stones" about the joints.

Of the earlier history of this case I could get no very distinct account. The patient suffered a good deal of pain in the affected wrist, the digestive functions were weak and disordered, the skin was dry and hot. The urine was high-coloured, very acid, and at times deposited uric acid crystals in large quantity.

I adopted the medico-galvanic treatment, and after the fifth application the pain ceased. This treatment was continued for two months, when the swelling was entirely removed and the motion of the joints perfectly free.

This was a very severe case; and the disease had proceeded so far that the deposition of urate of soda had commenced about the finger joints, as was shown by their *nodulated condition.*

About the same time that the above case was under my care, I had another patient suffering from symptoms of a precisely similar nature. It is therefore unnecessary to state more than that the same treatment was employed, and was attended with the same satisfactory results.

Mrs. B, æt. 66, a very stout corpulent woman, had many years ago been attacked with what at the time was considered acute rheumatism. After several attacks the disease assumed the character of rheumatic gout, affecting the finger-joints of the left hand; the wrist of which was stiff, swollen, and painful, as were the joints of the fingers, so that she had little or no use of them. The right hand and knee were also affected, but not so severely as the left hand.

Various modes of treatment had been adopted, from some of which she derived a little temporary relief. Her general health had suffered very much, and there was the usual train of symptoms common to this disease. The medico-galvanic treatment was adopted—galvanic currents were applied to each joint daily, and at the end of four weeks the pain and swelling in both the hands and fingers were completely removed.

To corroborate my statement of the power of galvanism in removing "chalk stones" when deposited around the joints, I may refer to the substance of a paper read by Dr. Bence Jones at the Royal Society, "On the Solution of Urinary Calculi by the aid of Galvanism." This paper contained the record of a number of experiments made to determine whether urinary calculi could be dissolved out of the body by placing them in dilute solutions of nitrate of potash, and then decomposing the solution in contact with the calculus by means of the galvanic battery.

Dr. B. Jones arrived at the conclusion that *uric acid* calculi can be dissolved by the aid of electricity at the rate of from two to nine grains an hour. That *phosphatic* calculi can be dissolved at the rate of from two to twenty-five grains an hour. That calculi, consisting of *oxalate of lime*, proved to be far less soluble, and they can be dissolved only at the rate of from half a grain to two grains an hour. The different calculi which had been the subject of Dr. Jones's experiments were exhibited, and afforded ample proofs of the solvent powers of electricity.

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